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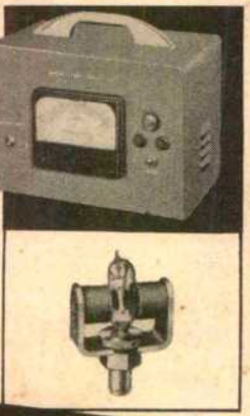

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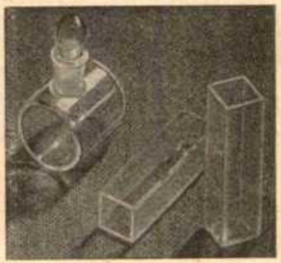

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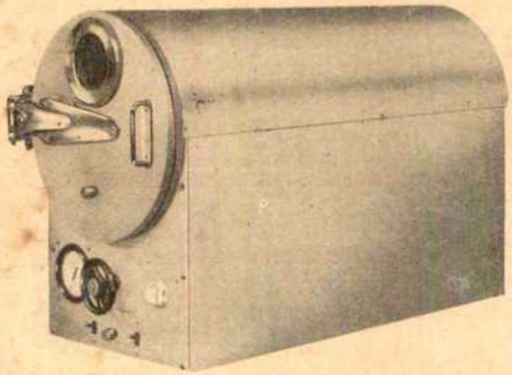

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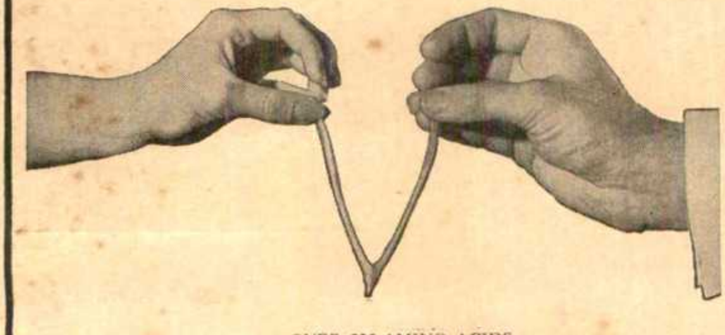

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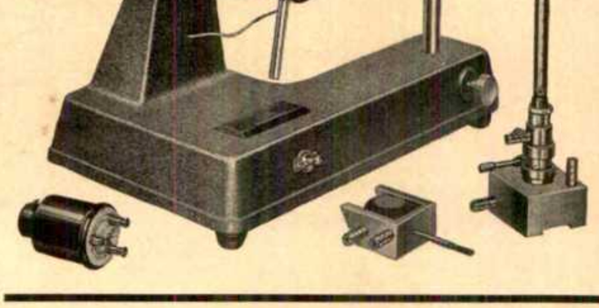

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REDUNDANCY IN INDUSTRY

IN a notable speech opening a long debate on the economic situation and wages at the Trades Union Congress on September 4, Mr. Alan Birch, chairman of the Congress's Economic Committee, after remarking that the trades unions' record of productivity was good, asked whether it was not true that too often co-operation and new methods in industry were regarded by the unions not so much as a positive thing for their own benefit, but as a concession to the employers. He suggested that the trades unions should use their organization to demand efficient organization and management, as well as to obtain a fair share in remuneration. He recognized that this meant a positive rather than a negative approach and that if the trades unions were to deal with the new problems posed to-day there must be a break with the approach developed when the unions were being built up and were on the defensive. Their industrial, economic and emotional approach must be based on the experience of the past two decades and not on that of previous ones.

Mr. Birch's views appeared to find little support in the general body of the Congress, but they are firmly supported by a study of redundancy, one of the problems specifically mentioned by Mr. Birch, which the Acton Society Trust has recently published*. This introductory survey of problems and practices associated with redundancy has been sponsored by the Society as part of its general plan of work, which seeks to obtain accurate factual knowledge about important contemporary developments in our industrial society so as to facilitate our understanding of the effect of such developments on individuals—their lives, their liberties, their values. Some of these problems arise from the increasing dependence of our industrial efficiency upon change and flexibility, and it is here that what have come to be known as problems of redundancy arise. Moreover, these are often very real human problems which must be handled with sympathy and understanding if, in a liberal society, progressive economic efficiency is to develop soundly.

In this study of the causes of redundancy, which is clearly distinguished from unemployment, its relation to the mobility or immobility of labour, its effect on individuals, and the measures which are being or could be taken to reduce the costs, material and psychological, which redundancy imposes, the Acton Trust is clear that the trades unions have a major responsibility. Redundancy is the involuntary loss of a job through no fault of the worker concerned. Since the redundant worker may be able to go straight into another job, it is not necessarily the same as unemployment; moreover, the unemployed will include some who have been dismissed for personal defects or have left of their own accord, and yet others who are seeking their first job. The problems of redundancy may indeed be sharpened by a depression, but throughout this survey it is assumed that full employment policy, in the sense of the maintenance of a general balance between the supply and demand for labour, is being successfully pursued.

Traditionally, the primary responsibility for coping with the effects of redundancy is the worker's own, and, in spite of arguments that it should not be his exclusively, it remains true that the responsibility for managing one's own life is inherent in the preservation of individual freedom. Nevertheless, it is consistent with this, and realistic, to argue that the trades unions have a major responsibility: on one hand, they should accept the inevitability of some redundancy, especially when a forward wage policy has produced an economy of increasingly costly man-power; and on the other, they should accept the responsibility for co-operating in handling redundancy so as to minimize hardship. Nevertheless, the survey fails to suggest that trades unions have been unreasonably backward in negotiating redundancy agreements. This may have been due to the backward view which Mr. Birch condemned, but it could also be due to the belief, held by employers as well as trades unions, that redundancy is often better handled at a local, rather than a national, level.

The Acton Society Trust makes two suggestions as to how the trades unions might help to reduce hardship and to encourage the best utilization of our resources. First, it suggests that the unions might pay greater attention to securing some form of protection against redundancy for their members, so as to safeguard them and make them less fearful of technical change. For example, the unions might negotiate a plan for compensation as a form of deferred pay, possibly safeguarded by establishing a redundancy fund. Secondly, and highly pertinent in the context of recent events, it is suggested that some attention should be given to the position of coloured people when redundancy occurs. The Trust regards this as a question about which the unions should make up their minds and then educate their members.

By and large, so far as the unions are concerned, their immediate contribution to the problem of redundancy seems to be a matter of education and a new outlook, and it once again indicates the critical importance of education, and especially of technical education. For the present, the survey stresses rather the responsibility of government and of industry. The former is regarded as having three aspects: the framing of general institutions and enactments where these impinge on industry so as to encourage rather than hamper the mobility of labour; the active assistance of mobility where public agencies can do so effectively; and the guaranteeing, as part of the general obligation of the Welfare State, of a minimum standard of living, through unemployment insurance and national assistance.

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* Redundancy: a Survey of Problems and Practices. Pp. vi+56. (London: The Acton Society Trust, 1958.) 5s.

It is on the degree of responsibility of employers that opinions differ most widely, but before considering the Trust's comments here and its further suggestions regarding the role of the Government, it is as well to consider what is implied in the objectives of a redundancy policy. The evidence of this survey suggests that hardship can best be reduced by paying special regard to the most vulnerable groups, particularly those in their late forties and early fifties, assisting people to get new jobs and helping them in the transition period. The second objective, that of encouraging the best utilization of man-power, can be achieved partly by making it easier for people to be mobile, especially geographically, and partly by bringing work to the workers where this is feasible.

The specific ways in which it is suggested that Government could further the achievement of these objectives are, first, through legislation, which requires employers to take such action as paying compensation or giving longer notice, the latter being possibly the more desirable. It might also be worth while to consider the feasibility of an insurance scheme to meet the contingency, and such a scheme might encourage a more responsible policy to redundancy and lay the real costs of uncertainty and instability where they properly belong. Secondly, changes in unemployment-pay, such as a higher initial benefit or the introduction of different contributions and benefits based on difference in earnings, as is done in Germany and Canada, is suggested, while fuller use and less-rigid application might well be made of the existing schemes for payment by the Ministry of Labour, in 'designated' circumstances, of removal expenses, fares and lodging allowances.

In its remaining suggestions for the role of Government, the pamphlet touches on joint responsibility with the employers and with the trades unions, and in both cases we are concerned with education. The publication, "Positive Employment Policies", issued earlier in the year by the Minister of Labour, is an example of what Government can do to exhort or educate employers to adopt responsible and adequate policies, while even more specifically the Ministry's training scheme depends on the goodwill of both the trades unions and the employers. The use of the scheme depends indeed on a more co-operative and progressive attitude on their part; it is a matter not simply of training or re-training the workers affected but of educating both unions and employers to face the responsibilities and new demands of technological change and development.

As regards the role of the employer, the Acton Society Trust takes the view, widespread and gaining ground among employers, that a firm is a social as well as an economic organization, with responsibility not only to its shareholders, but also to its workers, its customers, and to the wider community of which it forms part and through which it exists. In the light of this conception, three main points are made. First, with careful planning of man-power, the effects of redundancy can often be avoided or reduced, and even where this is not possible, longer notice can be given. Secondly, the employer, and especially the larger employer, can obtain information far more readily than the individual worker and therefore do much to assist and supplement the Ministry of Labour's efforts to find him other employment. Thirdly, in employing a man, employers incur not simply a liability to pay him for his work as it is performed week by week, but equally a liability to build up a reserve fund in respect of each man to cover either the employer's contribution to a pension or some form of compensation in the event of termination of employment before pension age is attained. The greatest need seems to be to endeavour to protect the older and most vulnerable employees through early pensions, or higher compensation where it is necessary to discharge them.

Employers can obviously help to reduce hardship by making, as some companies do, tide-over payments until a man has found a satisfactory job, and the survey finds some evidence of the great lengths to which some employers will go to ensure that the basis of dismissal is fair. It seems equally clear that there is room for such personal interest or touch and that its existence can make a most valuable contribution to the removal of hardship and any sense of dissatisfaction.

Finally, the pamphlet discusses the implication of the Government's policy for the distribution of industry and its bearing on mobility. Here it makes some sound remarks on the community aspect of the problem and points out that the failure to deal rationally with the reform of local government has hindered the dealing with the distribution of industry on its economic merits. It is too early to judge the effect of the Development of Industry (Industrial Finances) Act, though it is regarded as a useful addition to a development area policy which has become too rigid to meet present-day requirements.

Here, as well as the outstanding impression left by this preliminary survey, is the continuing need for fresh thinking and readjustment to changing conditions. Largely it is true that the initiative must rest with the Government, but the task of education required both to secure the essential mobility, the re-training and adjustment of labour to new occupations, the removal of restrictive and obsolete practices that hinder transfer and adjustment, is immensely varied and demands clear understanding and close co-operation on the part of both the unions and the employers. The vital importance of both technological and technical education is once again to be seen, both as a contribution to the supply of management of the high quality and wide outlook demanded, and to the supply of technicians and craftsmen, as well as technologists, of the flexibility and adaptability which an age of rapid technical change requires. It is, above all, on the vision and energy and urgency with which the expansion of technical and technological education is pursued that the ability of Britain to solve the problems of redundancy and to maintain its industrial efficiency ultimately depends.

SCIENCE TEACHING IN SECONDARY SCHOOLS

The Teaching of Science in Secondary Schools

Compiled by a Joint Committee of the Incorporated Association of Assistant Masters and the Science Masters' Association. Second edition, revised and reset. Pp. ix+274. (London: John Murray (Publishers), Ltd., 1958.) 17*s*. 6*d*. net.

THE original edition of this book dealt, in a practical manner, with every aspect of science teaching in the grammar type of secondary school. In the present edition every chapter has been revised thoroughly and the work is, in fact, a new book.

The original edition was the outcome of several years work by a committee which had the help of two hundred corresponding members. The present edition likewise is the fruit of the work of several years. Its appearance is timely, since so much thought is being devoted to the extension of science-teaching and to the place of science in the school curriculum. In particular, the new edition will prove most valuable because of the immense fund of practical experience available to the compilers on the design and equipment of laboratories and science rooms. When new schools are built or old schools are improved, teachers who act in a consultative capacity will find in this book a useful guide towards a solution of the problems which beset modern teaching laboratory design.

The work begins with a short history of science-teaching, and it is hoped that the future will see a separate volume dealing with the 'comparative' history of science teaching. It is useful to envisage the present system, with its difficulties and imperfections, through its history.

In the following chapter the aims of science-teaching are clearly stated. This is important, since so many so-called aims of education are entirely idealistic and theoretical. A pleasing feature of the book throughout its pages is that it keeps its feet firmly on the ground. Whereas the cultural value of science is stressed, its place in the competitive extra-mural world of technical achievement and economic survival is not forgotten.

Subsequent chapters deal in detail with the time desirable and available each year of the school course for teaching science, and the practical needs in the form of laboratories, demonstration, store and other rooms for schools of various sizes; plumbing, lighting, heating, ventilation, water, gas and electricity supplies are all considered in an expert manner. Even the acoustics of science rooms, floor materials, wall surfaces, doors, hatches and blackboards have reasonably adequate treatment.

There follows a chapter packed with information, presented succinctly, on apparatus and its maintenance, materials and safety precautions. Various methods of science-teaching are discussed and there is a very useful chapter on advanced-course work and preparation for university entrance. This is particularly valuable since the sixth forms of many smaller grammar schools are not adequately equipped, in materials and staff. A useful warning is given concerning the dangers of neglecting the mathematical background of the school sciences. Other sections deal with examinations, visual and other teaching aids, science in rural schools, first aid in the laboratory, the supply and training of science teachers, the science teacher and the law. The work concludes with a comprehensive bibliography.

There are some sensible and encouraging remarks on the training of science teachers, though one wonders where men and women with all the qualities and qualifications, given as necessary for the teacher of potential teachers, can be found.

The aims of 'methods' lecturers in science are two-fold: "first, there is the immediate aim of suggesting to the beginner appropriate methods of approach, describing good techniques for handling material so that it may make its full contribution to the education of the pupils. Secondly, the 'methods' lecturer is often faced with the task of doing his best to correct the unfortunate bias of some university courses. For instance, in many universities students are turned out without any knowledge of laboratory technique and are entirely ignorant of the subject in which they have been trained. The university course often concentrates on teaching skills and techniques applicable mainly to elementary research. The 'methods' lecturer endeavours to correct this by emphasizing the social and historical bases of science and by stimulating thought on more fundamental problems concerning the implications of science".

Not only should every teacher and potential teacher of science know this important book; but also it should be read by every head teacher and educationist with administrative, authoritative or senior status.

W. L. Sumner

ENZYMES AND RELATED TOPICS

Advances in Enzymology and Related Subjects of Biochemistry

Edited by F. F. Nord. Vol. 18. Pp. v+435. 9 dollars. Vol. 19. Pp. v+457. 9.85 dollars. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.)

THESE two volumes contain a pleasing selection of the several types of review for which "Advances in Enzymology" have acquired such an excellent reputation. Of the fourteen articles, two are detailed accounts of work on a single pure enzyme; seven discuss enzymes in connexion with particular metabolic systems, such as the tricarboxylic acid cycle, photosynthesis, or nitrogen metabolism; three are not specifically concerned with enzymes, but with related topics, namely, cytochromes, lipoic acid, and deoxyribonucleoprotein; and one deals with a group of enzyme inhibitors. In addition, the compilers of these volumes have followed an early tradition of including an occasional article on a process in which enzymes must surely be involved, although as yet virtually nothing is known of the enzymic stages; in this instance by including an article on lignification.

In Volume 18 the pure enzyme discussed is succinic dehydrogenase. Drs. Singer, Kearney and Massey give a clear account primarily of their own recent work on the purification and properties of this flavoprotein. Particularly interesting is their discussion of the role in this system of the iron associated with the flavin group; they suggest that the iron may be functional in some reactions catalysed by the enzyme but not in others. Next to this article is an excellent review by Dr. E. F. Hartree of the cytochromes in higher plants, most of which, of course, function enzymically in oxidation systems. It collects together all the work on the occurrence of cytochromes in various plant tissues, from the early classic work of Keilin and his collaborators to the more recent discovery of specialized plant cytochromes such as *f* and b_7. The function of these cytochromes as terminal oxidases, in photosynthesis, and in the transport of ions, is discussed in some detail.

Sir Rudolph Peters, in an account of the "Mechanism of the Toxicity of the Active Constituent of *Dichopetalum cymosum* and Related Compounds", develops the thesis that fluoroacetate and its analogues inhibit carbohydrate metabolism by a process of 'lethal synthesis', the enzyme inhibitor produced being fluorocitrate. The tricarboxylic acid cycle is also dealt with in a review, in French, by Prof. J. M. Wiame, on the importance of the cycle in biosynthesis, primarily in micro-organisms.

A very valuable article is that of Dr. H. L. Kornberg on "Pyrophosphorylases and Phosphorylases in Biosynthetic Reactions". It collects together into a logical system the considerable number of enzymes which have come to light in recent years which act on phosphorylated compounds at the phosphate linkage, either by transferring the phosphate or the remainder, or in a more indirect way bringing about the synthesis of a new compound at the expense of the energy of the phosphate linkage. There is a limited amount of detail about individual enzymes in the group, but very useful discussion of the possible intimate mechanisms involved.

Other articles in this volume are by Dr. L. J. Reed on "The Chemistry and Function of Lipoic Acid", by Drs. Butler and Davison on deoxyribonucleoprotein, by Dr. W. O. James on the respiration of higher plants, and by Drs. Schubert and Nord on lignification in higher plants.

Turning now to Volume 19, the article on the properties of a pure enzyme is by Drs. Kimmel and Emil Smith, on papain. This enzyme is of considerable commercial importance ; it was unknown to the present writer, until he read this account, that 500,000 lb. of crude papain, the product of more than 2 million papaya trees, are imported annually into the United States alone. It is also of considerable academic interest, since papain can be easily purified, especially as a mercury salt, and is a small molecule with a single peptide chain of 180 residues. These properties, together with the ease with which quantitative studies of its enzymic activities can be carried out, make it specially suitable for an attempt to relate protein structure and enzyme activity. Prof. Smith has himself made striking contributions to this end ; he has shown, in particular, that 120 ± 10 of the 180 residues can be removed from the N-terminal end of the chain without loss of all the enzyme activity. In this article, a plausible reaction mechanism is put forward on the basis of such studies.

Enzymic reaction mechanisms are also discussed at length in the review by Dr. H. S. Mason on "Mechanisms of Oxygen Metabolism". This long and in parts difficult account of enzymes 'activating oxygen', especially those introducing hydroxyl groups into cyclic compounds, contains a good deal of theory and speculation. It should prove very stimulating to those working in this field, and may provoke further experimentation along lines which will clear up the many present difficulties, especially the role of reduced coenzymes I and II in the action of hydroxylating enzymes.

Nitrogen metabolism is reviewed (in French) by Prof. Braunstein, of Moscow. He refutes the common idea that amino-acid metabolism involves simply the oxidative deamination of all amino-acids to give ammonia, which is immediately converted to urea. There is, in fact, a complex pattern of amino-acid metabolism analogous to the glycolytic and tricarboxylic acid pathways of carbohydrate metabolism. As well as a historical survey of earlier work, recent Russian work on the importance of vitamin B_6, together with some comparative studies on deamination, is presented. The activation of amino-acids is discussed, in German, by Prof. Wieland and Dr. Pfleiderer, who, among other things, give a good account of the chemistry of S-acyl derivatives of amino-acids, aminoacyl phosphates, and aminoacyl-adenosine-5′-phosphates.

The remaining article, actually the first in the volume, is by Drs. Vishniac, Horecker and Ochoa on "Enzymic Aspects of Photosynthesis". This contains, as well as a discussion of photosynthesis itself, a good survey of the known location in plants of the enzymes and coenzymes of carbohydrate metabolism as elucidated in animal tissues. This part of the article supplements that of Dr. James in Volume 18 already noted. The Calvin mechanism for carbon dioxide fixation, which has been reviewed elsewhere, is discussed at some length, but the emphasis is usefully laid on the occurrence of the enzymes involved.

Both Volumes 18 and 19 of "Advances in Enzymology" were published in the same year, and it is apparently the intention of the publishers to increase the previous frequency of one volume per year. This should enable them to keep them down to the present handy size. All in all, these two volumes maintain the high standard which dates from Volume 1 in 1941.

EDWIN C. WEBB

5-HYDROXYTRYPTAMINE

5-Hydroxytryptamine

Proceedings of a Symposium held in London on 1st and 2nd April, 1957. Edited by Dr. G. P. Lewis. Pp. xvii + 253. (London and New York : Pergamon Press, 1958.) 60*s*. net.

THIS is an account of a two-day international meeting organized at the instigation of the Co-ordinating Committee for Symposia on Drug Action. It was held at the Wellcome Foundation, London, in April 1957, and was the third meeting of this type, the earlier ones being on histamine and on hypertensive drugs. Nearly fifty research workers took part, and they included pharmacologists, physiologists, biochemists, pathologists and experimental psychiatrists.

5-Hydroxytryptamine is a substance of potent biological activity which is widely distributed in living organisms, being found in plants as well as in various species of animals. It occurs in many tissues, including blood platelets, intestinal mucosa, carcinoid tumours and in a number of vegetable and animal stings and venoms. This book contains a striking picture of the 'sting-print' of a nettle, made by pressing the leaf on filter paper and developing the spots of 5-hydroxytryptamine by chemical means. In this connexion, it is interesting to find that its biological activity is strongly antagonized by extracts of dock (*Rumex*) leaves. The symposium was divided into a number of sessions (with different chairmen as indicated), which dealt with the occurrence of 5-hydroxytryptamine (Sir Charles Harington), its metabolism and its cardiovascular actions (Dr. W. Feldberg), its other actions—concerned with nerve endings and ganglia, carcinoids, anaphylaxis and gastric secretion (Dr. Marthe Vogt), antagonists to its peripheral and central actions (Dr. B. B. Brodie), ending with a general discussion (Prof. J. H. Gaddum). Each group of papers was followed by its own discussion. It has sometimes been questioned whether, in symposia of this type, the reporting, more or less verbatim, of the spontaneous discussions is worth while. It was certainly worth while in the present symposium, for the discussions were lively, good-natured and free from trivialities but not from humour; moreover, they included a good deal of unpublished experimental material.

The volume is very well produced. It has an index —very brief, but better than none—and there are useful bibliographies at the end of the sections. The work on 5-hydroxytryptamine is scattered over a wide range of journals and it is valuable to have the more important findings collected together and discussed in this volume. D. C. HARRISON

FOSSIL MAMMALS

Traité de Paléontologie

Publié sous la direction de Prof. J. Piveteau. Tome VI: Mammifères: Évolution. l'Origine des Mammifères et les Aspects Fondamentaux de leur Évolution. Deuxième volume. Pp. viii+962 (1040 figures et 1 planche). (Paris: Masson et Cie., 1958.) Broché, 15,500 francs; cartonné toile, 16,500 francs.

THIS encyclopaedic work treats of the fossil placental mammals, except the Carnivora, Cetacea and Artiodactyla, which come in the first volume, and the Primates, which are allotted a separate Tome VII. Despite the title, there is nothing about the origin of mammals in the present volume, where the histories of some twenty-five orders, separate since the early Tertiary, are recounted in considerable detail, including a description of every genus.

Many of the contents have already appeared in an abridged form in Grassé's "Traité de Zoologie": the article on Proboscidea is reprinted verbatim from that work. Some sections, however, are new, notably J. Viret on the Perissodactyla, which is of a high standard; R. Hoffstetter on the Xenarthra, an excellent account; S. Schaub on the Simplicidentate rodents, which develops in full the classification already used in the "Traité de Zoologie", and R. Saban on the Insectivora, which uses a new classification. Mlle. C. Dechaseaux has contributed useful articles on endocranial casts, including some new material. There are also some interesting articles by Prof. Piveteau on drawings made by Palaeolithic man.

Together, these articles form a compendium of existing knowledge which will be of great value as a work of reference, particularly to research workers. The numerous illustrations will be especially useful to the advanced student, and the extensive bibliographies provide an excellent guide to the literature. However, the detailed treatment tends to obscure the evolutionary picture: the reader becomes overwhelmed by generic distinctions, and the authors have, on the whole, not taken sufficient opportunity to present synoptic and critical interpretations of the data. They are not altogether to blame: a considerable proportion of the fossil mammals are so poorly known that there is little on which to base an opinion of their relationships, and in many cases where the direction of evolutionary change has been established it has not been analysed functionally and ecologically.

Perhaps one of the principal functions of a survey such as this is to reveal gaps in knowledge and suggest lines for future research. It is not surprising that the phylogeny of the rodents and insectivores should be much less well understood than that of large forms like the Perissodactyla, but it seems anomalous that the order Proboscidea, where fossil material is relatively abundant and the general direction of evolutionary change is well known, should be classified on a frankly artificial basis. The predominance of teeth and jaws in the interpretation of fossil mammals becomes very evident when glancing through the illustrations in this volume, but functional interpretations of the dentition are noticeably lacking.

A work on so large a scale must inevitably be somewhat out of date by the time it is published. Few papers that have appeared since about 1955 have been incorporated fully, though a number are included in the bibliography. Recent work indicates that many of the primitive early placentals that have hitherto been classed as Insectivora are not closely related to the existing members of that group.

P. M. BUTLER

THEORETICAL GENETICS

An Introduction to Genetic Statistics

By Prof. Oscar Kempthorne. (A Wiley Publication in Applied Statistics.) Pp. xvii+545. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 102*s*. net.

THE division is already familiar of physics—and physicists—into the theoretical, or mathematical, and the experimental; and it is becoming so in chemistry, too. Among the biological sciences, there can be little doubt that genetics will be the first to go this way and indeed there have been signs that it has begun to do so, for mathematical treatments of theoretical problems are no novelty in the genetical literature. Dr. Kempthorne's book marks a further significant step in this direction.

In so far as the title, "An Introduction to Genetic Statistics", suggests an account of the statistical methods used in tests of significance and the estimation of genetics parameters, it could be misleading. True, these methods are described, at times in some detail; but the bulk of the book is devoted to the mathematical development of genetical concepts, theories and problems. Mating systems, inbreeding, and population problems are all covered, often in a wealth of detail. Thus inbreeding systems are handled both by what may be termed the direct method, which Malécot has largely developed, and by matrices, these being used as an introduction for the geneticist to matrix algebra. To many, however, the great appeal of the book will be its very full treatment of the theory of biometrical genetics both in populations and in the descendants of deliberately crossed inbred lines. The treatment is always as general as the author can make it, often going well beyond anything that has yet been thrown up by experiment, and indeed a considerable body of new work is here presented for the first time. Some topics, for example genotype-environment interactions, do, however, appear thus far to have eluded Dr. Kempthorne's interest.

The author says that "the prerequisites of the book are essentially nil if . . . all readers will have had high school algebra". He surely over-estimates either the content of "high school algebra" or the progress achieved by the average geneticist during his school days. Few, in fact, will fail to find Dr. Kempthorne's text to be hard going, and many geneticists will undoubtedly give it up in despair. They will, however, be the losers if they do so. It is essentially a theoretical mathematical treatise: arithmetic is seldom used and never where algebra can be made to serve. Experimental data are at a discount. The level of genetics assumed appears to be lower than the level of mathematics, and the genetical definitions are commonly less precise than the mathematical. The mathematically more elementary chapters are so much more scrappy than the advanced that one inevitably feels the author to have found them so much less interesting to write. The occasional biological gloss, as where a footnote asserts that bees, oysters and snails may be self-fertilizing like plants, gives an impression of archness rather than of accuracy or understanding. But this should neither surprise nor irritate, for Dr. Kempthorne is a mathematician. Rather, we should be grateful that he has devoted his mathematics to developing genetics in a way which all but the merest few geneticists can but accept without hope of emulation. The result is neither elementary nor easy. It will seldom be read for pleasure. But it cannot fail to command respect as a source of constant and indispensable reference for all concerned with the theory of population and biometrical genetics; and it cannot fail to make one wonder how long away is the day when we must recognize, albeit regretfully, that theoretical and experimental genetics have become different, though cognate and complementary, disciplines and skills.

KENNETH MATHER

ANTARCTIC METEOROLOGY

Meteorology of the Antarctic

Edited by M. P. van Rooy. Pp. xi+240+8 plates. (Pretoria: Weather Bureau, Department of Transport, 1957.) n.p.

DURING the past ten years the South African Weather Bureau has done much for Antarctic meteorology. The Royal Naval Weather Service had shown that a useful synoptic chart could be drawn, and the Weather Bureau finds that in spite of shortage of data from some areas a reasonably good chart can be drawn for the whole of the southern hemisphere, especially during the whaling season when the factory ships make regular reports from the higher latitudes. It has not been able to undertake the labour and expense of issuing a daily analysis, but since 1952 it has published basic data for climatological studies and research in its own journal, *Notos*. One of its aims has been to persuade meteorologists from the northern hemisphere to take a more active part in the work, and the new compendium is intended to give as much help as possible to those engaged on expeditions to Antarctica during the International Geophysical Year. It includes a useful account of the main geophysical features and climates of the Antarctic continent, islands and surrounding ocean and of what is known of the surface currents. It shows where previous meteorological data can be found and deals with the special problems of observing under Antarctic conditions.

Discussion of the available data occupies most of the book. W. L. Hofmeyr, studying the distribution of atmospheric pressure at sea-level, directs attention to the deep circumpolar trough all around the Southern Ocean centred in about 62° S. in summer and 64° S. in winter, and tending to be farther north in the Atlantic sector than in the Pacific sector. The only counterparts in the northern hemisphere are the oceanic lows over Iceland and the Aleutians; elsewhere the effect of the land-masses tends to equalize the north–south gradient. The charts accompanying the work seem to indicate a weak tendency for similar smoothing in sectors of the Antarctic where the continental coast has its strongest north–south trend. It is shown that the anticyclone over the continent should be considered as a prevailing but not uninterrupted condition, since wandering cyclones can enter it.

Dr. Loewe shows that existing information about precipitation and evaporation is inadequate for a study of the balance between them. Apart from the scarcity of observing stations and absence of regular shipping lanes, the difficulties of measuring rainfall at sea and snowfall on the continent are very formidable. E. Vowinckel's study of the climate of the Antarctic Ocean gives a clear indication that the ocean currents and surface temperatures are the predominant factors; the same is true for the islands the climates of which are usefully outlined in the next chapter. Around the coast of the continent the differences between one region and another seem to depend more on varying exposure to continental and oceanic influences and on seasonal changes in the limits of the pack-ice. The variation is particularly great in the Graham Land region. This area is given special attention because of the greater abundance of observations. A pioneer chapter by W. L. Hofmeyr on the upper air conditions shows that the circulation pattern is simpler than that of the northern hemisphere and the heat exchange between the pole and lower latitudes appears to be less effective. A final chapter deals with the history and problem of weather map analysis. In listing the twelve deepest lows that have been recorded south of 50° S., it overlooks one of 927·7 millibars reported by the R.R.S. *Discovery II* from the Bellingshausen Sea on October 30, 1932, second only to 923 millibars reported from Adélie Land in September 1951.

The folding map which accompanies the book is not always identical in detail with other recent publications and its contours, though tentative, may give too positive an indication of the postulated Ross–Weddell Graben. The map overlooks the existence of Peter I Island, which would be a more useful station than some of those in Graham Land. The eleven chapters and references constitute a very valuable compendium.

Although Antarctic meteorology is being continually furthered in a qualitative way by skilful arrangement of the growing wealth of data, the work has to be done with rather superficial guidance from physical principles. Even in the northern hemisphere, where there is a close network of observations, meteorologists have emphasized the growing belief that we might do better in the long run by trying to find out what kind of behaviour the laws of Nature prescribe. In the Antarctic, where it is difficult to get more observations, such guidance seems very desirable. The relatively simple arrangement of land and ocean favours systematic physical study. To make much progress the atmosphere and ocean must be studied together, and qualitatively the Antarctic Ocean is known as well as if not better than the atmosphere. Results of universal importance might readily be obtained there, but the work would involve a joint meteorological and oceanographic expedition to the ocean rather than to the land, including studies of the transfer of heat and momentum, and quantitative investigations of the circulation of the deep water as well as that of the upper air. G. E. R. Deacon

ANNUAL REVIEW OF PHYSIOLOGY

Annual Review of Physiology, Vol. 20

Edited by Victor E. Hall, in association with Frederick A. Fuhrman and Arthur C. Giese. Pp. viii+633. (Palo Alto, Calif.: Annual Reviews, Inc., and the American Physiological Society, 1958. On sale by Annual Reviews, Inc.) 7 dollars.

According to the preface in this twentieth "Annual Review of Physiology", the total number of articles of biological interest has increased during these twenty years from 77,000 to 145,000 a year, and the number of papers reviewed has increased during the same period from 4,256 to 5,543. The size of the volumes published has remained almost constant, and the number of words per paper has fallen. These figures show that the authors have been more selective than some people supposed, and present an awful picture of the amount of literature which a physiologist might study if he had the time—nearly four hundred papers a day.

The prefatory chapter is written this year by W. J. V. Osterhout, and gives an interesting summary of some of the fundamental work he has done on the physiology of aquatic animals since he first became interested in the subject sixty-six years ago. About half the remaining twenty articles deal with main branches of physiology—circulation, respiration, reproduction, digestion, excretion, temperature, and the central nervous systems, and provide new instalments of serial stories which are contained in each volume. There is a series of articles on different aspects of Russian physiology; last year Russian neurophysiology was discussed, this year cardiovascular aspects are considered, and next year we are promised an article on metabolism and endocrinology. Those who cannot read Russian are thus given an opportunity of finding out what they are missing. Comparative physiology is represented this year by an article on excretion; last year it was osmotic regulation and next year it will be blood pigments and biological clocks.

In addition to these standard subjects, there are various other articles of special interest this year. There are articles on growth by J. A. Russell and A. E. Wilhelmi, on the physiology of the skin by W. B. Shelley and R. P. Arthur, on synaptic transmission by W. D. M. Paton, on the hypothalamus, adenohypophysis and adrenal cortex by G. Sayers, E. S. Redgate and P. C. Royce, and many others by well-known authors.

The editors are to be congratulated on maintaining so high a standard. Some people think that this volume is little more than an uncritical reproduction of a card index; but some of these articles are much more than this and give a balanced picture of the best modern work. Anyone who hopes to keep in touch with a wide field of physiological work will derive benefit from this book. J. H. Gaddum

HORMONES IN BLOOD

Ciba Foundation Colloquia on Endocrinology

Vol. 11: Hormones in Blood. Edited by G. E. W. Wolstenholme and Elaine C. P. Millar. Pp. xii+416. (London: J. and A. Churchill, Ltd., 1957.) 56*s*. net.

Starling defined a hormone as a substance produced in one part of the body to be carried by the circulating blood to another part, where it elicited a physiologically important response. He believed hormones to play an important part in the mechanisms responsible for the co-ordination of function in the body, and time has emphasized the soundness of this belief. Since the time when Aschheim and Zondek found that the urine of pregnant women contained gonodotropic and œstrogenic substances, there have been got from all sorts of urine many materials which possess activity similar to that of extracts of endocrine glands; but, unfortunately, it has not always been remembered that the substance in urine is not necessarily that secreted by the endocrine gland. Moreover, chemists have synthesized substances, for example, diethylstilbœstrol, which, weight for weight, are more physiologically active than hormones when injected into animals or man. This fact has in some instances turned attention from natural hormones to cheap and easily obtained substitutes which may be of particular therapeutic value. The sub-title of the colloquium on which this book is based could have been "Back to Blood", since a study of the hormonally active substances in blood is likely to be more relevant to the problem of what is a hormone in terms of Starling's definition than the identity of active substances present in urine or solely the product of the chemist's ingenuity.

But, as often happens, a step nearer to the problem that can be formulated brings to light others that previously were not so clear.

In some instances, perhaps in many, the substance circulating in the blood is not identical with that which brings about a physiological effect in the tissues, that secreted by the endocrine gland being altered before entry into the tissues where it acts. Thus, Starling's definition may need extension and expansion; but definitions, valuable though they be, often make a cloak for ignorance. This volume is the record of a most thorough and illuminating discussion by experts of how interest has shifted from urine to blood, and is already beginning to move from blood into the tissues, where the processes involved in the control of metabolic functions actually take place. What is precisely meant by the word 'hormone' becomes less certain as a result, but the book conveys excellently the excitement of uncertainty in a rapidly developing and expanding field of research.

F. G. Young

An International Symposium on Aldosterone

Edited by Alex F. Muller and Cecilia M. O'Connor. Pp. x+232. (London: J. and A. Churchill, Ltd., 1958.) 40*s*. net.

IN June 1957, the Clinique Thérapeutique of the University of Geneva organized an international symposium on aldosterone. This book is a record of the papers given and the discussions which they produced. Aldosterone is one of the hormones of the adrenal cortex which is concerned in the regulation of the level of electrolytes, and its secretion appears to be influenced directly by changes in the water and electrolyte balance of the body. One of the main problems in the study of the functions of aldosterone is the difficulty of estimating it with reasonable accuracy in body fluids and tissues, and this question was discussed in the first part of the symposium. In other papers, the biological action of aldosterone was compared with that of other related hormones and work was described on the synthesis of aldosterone by tissues *in vitro*. The second day of the meeting was devoted mainly to the clinical and biochemical findings in patients with an abnormality in aldosterone secretion.

Some of the communications illustrate vividly what a lot of information on aldosterone has been obtained by the use of very small amounts of this scarce material. A particularly striking paper describes how aldosterone labelled with tritium was prepared by incubating correspondingly labelled progesterone with capsule strippings from ox adrenal glands, and how the resulting radioactive aldosterone was then used to study the metabolism of the hormone in the body.

Those interested in the steroid hormone field will be glad that the proceedings of this symposium have been made available in book form, especially as much of the experimental work appears here in print for the first time. It would have been helpful if a figure had been included, showing the structural relationships between the various steroid hormones discussed. All the papers and discussions are in English.

D. C. HARRISON

Guide to Unpublished Research Materials

Lectures delivered at a Vacation Course of the University of London School of Librarianship and Archives in April 1956. Edited by Ronald Staveley. Pp. vii+141. (London: Library Association, 1957.) 21*s*. (15*s*. to L.A. members.)

THIS volume, which is complementary to an earlier publication in 1952, "Government Information and the Research Worker", is intended to assist the staff of research libraries and others who collect and use the records of research. The lectures are arranged in two parts. In the first, dealing with science and technology, Mr. A. H. Holloway contributes an introductory chapter on the research report, in which, although the problems of such reports, including the secrecy aspect, when emanating from Government sources are fairly presented, the industrial aspects are largely ignored; nor are they adequately discussed in the following review of materials and sources of the United Kingdom by J. C. Malloch and R. J. Brierley. Mr. A. N. Holloway deals with the research report in North America, while Dr. A. L. Mackay's account of materials and sources of Eastern Europe and China relates largely to published as well as to unpublished sources. A paper by E. J. Offord on the United Kingdom's participation in European Technical Information Projects replaces that delivered in the course.

The remaining seven lectures deal with the social services. Miss Barbara Kyle discusses bibliographical control of unpublished material; L. T. Williams, statistical material and sources; T. Carter, sources in market research; B. D. Copland, the advertising agency and the interchange of information; R. O. Godwin, market research in industrial fields; W. L. Guttsman, who draws largely on published sources, with materials and sources in sociology; and C. M. Franks, with materials and sources in psychology.

From the factual point of view the volume should achieve its purpose and it directs attention to the new function of the Technical Information and Documents Units of the Department of Scientific and Industrial Research as the national centre for receipt of unpublished research materials from other members of the Organization for European Economic Co-operation. Nevertheless, the value of the volume would have been enhanced by a more critical and forward-looking approach to the character of unpublished material. Generally speaking, the adequacy of existing methods of publishing and handling information is accepted without questioning their appropriateness to the needs of the research worker, or to modern techniques of handling and distributing information.

R. BRIGHTMAN

Elements of Partial Differential Equations

By Prof. Ian N. Sneddon. (International Series in Pure and Applied Mathematics.) Pp. ix+327. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 56*s*. 6*d*.

THIS is essentially a user's book; its main aim is to provide an account of methods whereby special solutions of the famous equations of classical mathematical physics may be derived, and to connect these solutions with physical problems. A good honours student with an interest in applied mathematics should find the book to his taste, and easy to read.

An introductory chapter deals with ordinary differential equations in two or more independent variables; the account of Pfaffian forms is excellently illustrated by Carathéodory's formulation of the basic principles of thermodynamics. The simpler classical processes for the solution of partial differential equations, such as those of Charpit and Jacobi, are discussed in the second chapter, and in the third a survey of second-order equations is given. The remaining three chapters attack the central theme of the book: Laplace's equation, the wave equation, the diffusion equation. Considerable emphasis is laid on the use of Green's function; the treatment is elementary but forward-looking, and should encourage the student to make a deeper study of the connexion with integral equations and integral transforms, a connexion which Prof. Sneddon insists on frequently but cannot pursue in great detail in an elementary account. Pains have been taken to bring in such modern methods as can be explained in reasonably simple terms; fundamental theory is carefully explained, and key theorems are either proved in full, or the need for such proof pointed out and references given.

Physical problems are used to introduce the appropriate equations, to illustrate the theory, to provide worked examples and to furnish a respectable but not overwhelming number of exercises for the student.

T. A. A. BROADBENT

PEACEFUL USES OF ATOMIC ENERGY

UNITED NATIONS CONFERENCE AT GENEVA

THE second United Nations Conference on the Peaceful Uses of Atomic Energy far outstripped the first Conference in the number of papers presented and the number of participants. The scope of the Conference was widened by the inclusion of six 3-hr. sessions on controlled fusion research, and this provided some of the most stimulating new information at the Conference. The discussion of this subject was greatly helped by the final stage of declassification of this field of research by the United States and the United Kingdom. The U.S.S.R. presented to the Conference four volumes containing one hundred papers describing the results of their fusion research up to the present time, and also gave some information about their recently completed large-scale fusion devices. New sessions were included on the separation of isotopes by diffusion plants and centrifuges and other methods, but the continued classification of diffusion plant technology reduced the scope of discussion in this field.

An outstandingly successful scientific exhibition was held in a specially built prefabricated building in the grounds of the Palais des Nations. The United States showed at least ten working fusion experiments from Livermore, Los Alamos, Oak Ridge and Princeton, and this was immensely valuable in enabling scientists to grasp the principles of the many different approaches to controlled fusion. The principles of construction and operation of reactors were equally well shown. The U.S.S.R. showed models and photographs of their latest fusion devices, their nuclear propelled icebreaker and their power stations in construction. The French showed models ranging from their pilot diffusion plant to their nearly completed propane bubble chamber for working in high-energy physics. The United Kingdom exhibition was modest in size compared with the United States exhibition but high in quality. It included a one-third scale model of ZETA, a working model of a 'fast pinch' fusion experiment from the Atomic Weapons Research Establishment, a wide range of scientific exhibits, and models illustrating new reactor developments.

A large industrial exhibition was organized in the city, and eighty-four British firms contributed a very impressive range of exhibits.

Many new scientific films were shown at the Conference, including films describing applications of radioisotopes in the United Kingdom; the United States and U.S.S.R. programmes of controlled fusion research; and the first full-scale 100-MW.(E) nuclear power station to operate in the U.S.S.R. This power station has been built together with a new town on some undisclosed site in Siberia. It is ultimately to have six similar units.

Sessions on nuclear power described the operating experience acquired during the past three years on the prototype power stations, Calder Hall and Shippingport, and the progress which is being made in the construction of the world's first nine full-scale nuclear power stations. These are of five main types —the U.S.S.R. graphite-moderated water-cooled reactor, the United Kingdom graphite-moderated gas-cooled reactor, the United States pressurized and boiling-water reactors and the United States 100 MW.(E) fast reactor. The boiling-water reactor is growing in favour owing to the success of the United States experiments. Its capital cost seems likely to be 30 per cent below the cost of the pressurized water reactor power stations.

The Canadians and the Czechs are developing the heavy-water-moderated reactor cooled either by steam or gas or heavy water. The Canadians believe that they can use fuel of natural uranium oxide and achieve fuel costs of about one mil.

The economic sessions showed that the date at which nuclear power costs are expected to achieve parity with conventional power costs ranges from 1962 in the United Kingdom—for the 500 MW. station remote from coalfields—to 1972 or thereabouts in the United States, where nuclear power has to compete with cheap hydro power and low fossil-fuel costs in many areas. Nevertheless, it appears that 15,000 MW. of nuclear power capacity will be installed by 1965–70. In the group of 'underdeveloped countries', India and Japan will take the lead and expect to have 500 and 750 MW. installed, respectively, by 1965.

Descriptions were given of the more advanced types of nuclear power stations which have reached the reactor experiment stage. The reactor using an organic liquid as a moderator is showing promise as a simple low-pressure system with potential application to propulsion and small power units. The aqueous homogeneous liquid uranium salt fuelled reactor of Oak Ridge has had troubles due to failure of welds in the inner core vessel and has now some difficulty with the stability of the liquid fuel. The graphite-moderated sodium-cooled reactor experiment is providing experience in liquid-sodium technology as well as experience in operating metallic fuel elements at higher temperatures than have been used hitherto. The United Kingdom reported on the next stage of development of the United Kingdom power reactors. The advanced gas-cooled reactor, which is being built to operate at fuel element temperatures of 600° C. using uranium oxide fuel, was discussed. The next stage, the high-temperature gas-cooled reactor project, aiming to use all-ceramic elements and to produce outlet gas temperatures of 700° C., was also described. This reactor experiment may be built at Winfrith Heath as an Organization for European Economic Co-operation project. Experiments on the stability and physics of the fast reactor and the construction of a full-scale 100 MW.(E) fast reactor in the United States and plans for fast reactors of 50 MW. and 250 MW. output in the U.S.S.R. were described.

The Conference received reports on the first semi-commercial nuclear propelled ships. The United States *Savannah*, coming into commission in 1960, will use a pressurized water reactor developing 22,000 shaft horse-power. It will carry up to a hundred passengers and is estimated to cost 30 million dollars, so it is far from being economic. The United States expect also by 1962 to install a boiling-water reactor in a tanker in the hope of reducing capital costs of the propulsion unit to a figure nearer parity with conventional units.

The U.S.S.R. reported on their icebreaker *Lenin*, which will come into commission in 1959. This will have three pressurized water reactors, one stand-by, and 44,000 shaft horse-power will be developed. This icebreaker will open up a 6,000 mile seaway north of the U.S.S.R., an application which would be impossible without nuclear power.

The controlled fusion sessions and the exhibition dealt with experimental devices falling into two main classes. The first class use the pinch effect to confine a hot conducting deuterium plasma in a toroidal or straight tube. Heating is carried out by resistive heating, shock-wave or compression heating, and radio-frequency heating. Under some conditions—when high electric fields are used to maintain the current—large bursts of 5-kV. X-rays were observed, believed to be due to runaway electrons. This produces a serious loss of energy in the plasma. Ion temperatures of several million degrees were reported with electron temperatures much lower. The maintenance of stability and containment of the hot plasma as energy input is increased is the crucial question for the future development of this class of fusion devices.

The U.S.S.R. reported that they had recently completed ALPHA—very similar in size and appearance to ZETA—in a Leningrad laboratory.

The second class of devices is the 'Mirror Machine', in which the hot plasma is also contained by magnetic fields. In one of these devices, the D.C.X., the hot plasma is formed by injecting 600-kV. molecular ions, and stripping them into atomic ions and neutral atoms in an intensely powerful carbon arc. The neutral atoms leave the chamber and the atomic ions are trapped by the magnetic field and convey their energy to the plasma. The U.S.S.R. have a giant version of this just complete, which they call OGRA. In OGRA the molecular ions spiral in a long path to and fro between magnetic mirrors, and it is hoped that they will be dissociated by impact with neutral atoms. The original mirror machine, the pyrotron, heats the plasma by compressing it with magnetic fields—working like magnetic pistons. A delightful small mirror machine from Los Alamos, SCYLLA, compresses a plasma by a very short pulse magnetic field, produced by a condenser discharge in a fraction of a microsecond. The machine was working in the exhibition, producing pulses of neutrons, activating silver foils the subsequent decay of which the admiring crowds could follow.

In a variant of the mirror machine from Berkeley, ASTRON, amperes of multi-million volt electrons are to be injected into a chamber and constrained to follow a path which will produce, by a combination of their magnetic fields with the external field, a stable 'magnetic bottle' which it is hoped will enable a high-temperature plasma to be formed by electron collisions.

The mirror machines, like the pinch machines, will depend for their success on maintaining the tenuous plasma, generating perhaps hundreds of megawatts per cubic metre in a relatively quiescent state. The energy generated may be of the same order as in fission reactors, but instability time constants could be many orders of magnitude smaller.

So far, although lots of fusion neutrons have been produced by these devices, no laboratory has claimed that they are true thermonuclear neutrons. Ion temperatures of several million degrees have been reported, with electron temperatures much lower for some of the pinch machines. Mirror machines have produced electron temperatures of ten million degrees, but ion temperatures are so far unknown. The true thermonuclear neutrons are evidently 'just around the corner', but it is probably a long haul from them to reach the break-even point when energy output from the plasma equals the energy input. Thermonuclear power stations seem at least twenty years away, but the subject has excited such intense interest and experimental activity that predictions based on present knowledge may soon be out-dated.

The biological sessions were well attended, and the material presented was much newer and fresher than in the 1955 Conference when ten years of work was reported. One of the most interesting reports came from the Oak Ridge Laboratory, on the radiation-induced mutation-rate in mice. Hitherto the direct proportionality of gene mutation with dose of radiation has been accepted as a law which holds, irrespective of dose-rates, down to the lowest accumulated doses. W. and L. B. Russell produced evidence for departure from linearity in the relation between mutation-rate and dose for point mutations in the spermatogonia of male mice. Furthermore, they showed that the mature egg cell of female mice is substantially less sensitive to the induction of mutations than the spermatogonia of the male. Similar results have recently been reported by Carter from Harwell. These two facts will probably necessitate a complete reconsideration of the quantitative predictions of the genetic hazard.

The rapidly expanding application of radioisotopes was shown in eight sessions. At the 1955 Conference, Glascock pointed out the potential importance of tritium as a label to supplement the use of carbon-14. This was borne out by a description in this second Conference of the incorporation of tritium into thymidine in order to build a specific label into the nucleoproteins of cell nuclei. Tritium with its very low-energy beta-emission allows very precise localization by the autoradiographic technique. Already this is providing direct evidence on cell nuclear processes which formerly were merely inferred from indirect considerations.

Clinical medicine benefits in the same way from the application of radioactive tracers to problems of diagnosis and the measurement of individual body-functions. The physician is no longer limited to identification of what goes in and what is excreted; he can trace intermediary metabolism *in vivo* by direct counting or by sampling tissues or body fluids. A notable contribution to the Conference was the increasing accent on the use of shorter-lived radioactive isotopes in order to reduce the radiological dose to the subject. Ingenious, too, was the application of oxygen-15, produced in a cyclotron, for investigating malfunction of the lung. The isotope pill for diagnostic purposes predicted by Dr. Libby was demonstrated in the exhibition.

The industrial uses of radioisotopes continue to increase rapidly. The applications to industrial chemistry are among the most important new fields. Sources of radiocobalt in strengths of the order of 100,000 c. will soon be available and will be followed by radiocæsium extracted from atomic wastes. Promising applications to the production of graft polymers, vulcanization, sterilization and food preservation were described and illustrated in the exhibition. Radioactive catalysts were reported to increase yields several fold.

The sessions on fundamental research were instructive and entertaining. The Dubno 12-GeV. accelerator and the Saclay 3-BeV. accelerator were described. Cosmic ray workers flying large stacks of photographic emulsions in Comet proving trials have been able to obtain an enormous amount of new data on the collision of protons ten thousand times more energetic than any which can be produced by the largest planned accelerators. The demonstration, by the orbiting satellites, of the existence of intense belts of 40 MeV. protons, a thousand kilometres or so above the Earth in particular latitudes, was also described. The great question of why pions and nucleons exist with their particular masses and particular interactions was said to remain totally unanswered, in spite of the wealth of new knowledge produced by the accelerators. Dr. Feynman gave an entertaining account of the strange particles, which now total thirty-one. The theoreticians have a new occupation of inventing new rules and waiting to see whether the latest strange particle obeys them.

In the field of nuclear data the present situation leaves no room for complacency, since present reactor technology requires much more precise information which we shall have to work hard to obtain. To help in this, important new tools such as the Harwell linear accelerator and neutron booster providing enormously powerful pulses of neutrons are becoming available.

In the chemical sessions an account was given of the isolation of weighable amounts of berkelium; chemists look forward to going well beyond element 102, aided by expensive reactors with neutron fluxes up to 10^{16} per cm.^{2} per second. The chemical effects of fission fragments appear to be much higher than anticipated, and this may have important technological consequences. There has been a rapid advance in solvent-extraction technology, and long-chain amines and long-chain derivatives of phosphoric acid have been synthesized with highly specific activities.

A great deal of new and valuable information was obtained at this Conference, not only from the lectures but also from the exhibition and films, which made it possible to see in a few days, in an exciting visual way, work proceeding throughout the world. The Conference provided the opportunity for innumerable discussions in small groups to supplement the work of the formal sessions. Future accelerators, the future of modern physics, genetics, plasma physics throughout the world, the future of co-operation in atomic energy in the Commonwealth, in Europe and in the world, and numerous other topics were discussed. The very rich feast taxed our physical and mental endurance.

There has been much informal debate as to whether there should, in three or four years time, be another conference on this scale or larger. On one hand, it was argued that only by having a conference of such wide scope can one persuade Governments to provide the finances for the immensely rewarding exhibitions and to release new information, and also persuade individuals to write up their research in a form suitable for presentation to the world. It was generally agreed that much cross-fertilization between the different ramifications of atomic energy resulted. All this is true enough and we will need to balance this against the great effort and interruption of research work required to prepare for these conferences. After a few months of thinking over the result, we may be better able to decide.

We are, however, all sure that the Conference was immensely worth while. J. D. COCKCROFT

AIR SHOWERS OF SIZE GREATER THAN 10^5 PARTICLES

(I) CORE LOCATION AND SHOWER SIZE DETERMINATION

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CURRENT observations on the extensive air showers of cosmic rays[1,2] are concerned with two main problems. In the first of these, the cosmological problem, observations are made in order to determine what anisotropies may exist in the directions of incidence of the high-energy primary particles which initiate the showers, and whether there exists a high-energy cut-off in the energy spectrum of these primaries. Such observations have led to the development of large-area detectors of air showers in order that giant air showers, corresponding to primary energies greater than 10^{16} eV., may be detected with appreciable frequency. The second problem is the investigation of the high-energy nucleon–nucleus interactions of the primary and secondary nuclear-active particles in the air, interactions which give rise to the development of the air shower detectable in the lower atmosphere, and here may be considered showers of a more modest size, detectable with sufficiently high frequency with arrays of smaller dimensions.

In order to provide information on the second of these topics, observations were commenced in Sydney at the beginning of 1957 on the properties of showers of size 10^5 particles and greater. Because of the dimensions of the apparatus and of the range of particle densities which can be measured by the detectors, and also because of the rapid decrease of the frequency of showers with increasing size, these

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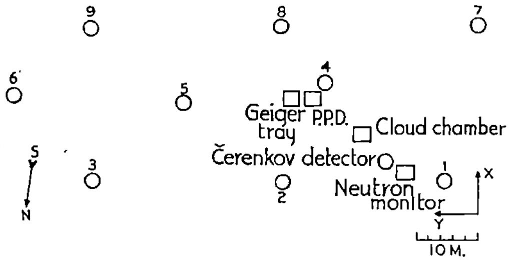

Fig. 1. Plan view of air-shower array. The circles numbered 1–9 represent the liquid scintillation counters. The triggering Geiger trays (not shown) are grouped around the cloud chamber

observations cover an effective range of shower sizes from 10^5 particles to 10^7 particles. Several different instruments are used for detecting the various types of particles in the air showers, for measuring their local density and in some instances for providing information on their directions. These instruments include a large Wilson cloud chamber, an unshielded tray of Geiger counters, a detector of penetrating particles consisting of an array of hodoscoped Geiger counters in a lead pile, a multi-element atmospheric Čerenkov detector, and a device for registering the counts given by a neutron monitor in the period immediately following a shower.

To be able to interpret the results obtained from these instruments, in terms of the structure and development of the shower, it is necessary to know the size of the shower, and the position of its core and the direction of arrival relative to the c ting instruments.

This article describes the array of dete s, the recording gear, the calculations used to in the first two of these quantities, and gives so details of the performance and accuracy of th ystem. The determination of the shower directio will be dealt with more fully in a later publicati

The Array of Detectors

For reasons of cost and convenience, th paratus has been placed on the roof of the U rsity of Sydney School of Physics, and on thre telegraph poles adjacent to the building. The array comprises nine liquid scintillation counters, each of 0·23 m.^{2} sensitive area and 10 cm. depth, arranged in a rather irregular manner, dictated by the topography of the site, inside a rectangle 70 m. × 30 m. The counters are about 20 m. apart (Fig. 1).

These counters are used for giving a measure of the density of the air shower particle flux, by giving an electrical pulse the height of which is proportional to the number of electrons traversing the counter. Some details of their response to the air shower flux have been described elsewhere[3]. As well as the nine density measurements provided by these counters, the time of arrival of the particles is measured in four of the counters, numbers 2, 3, 8 and 9. The difference in these times is used for determining the plane of the shower front, and hence, the direction of the shower axis[4].

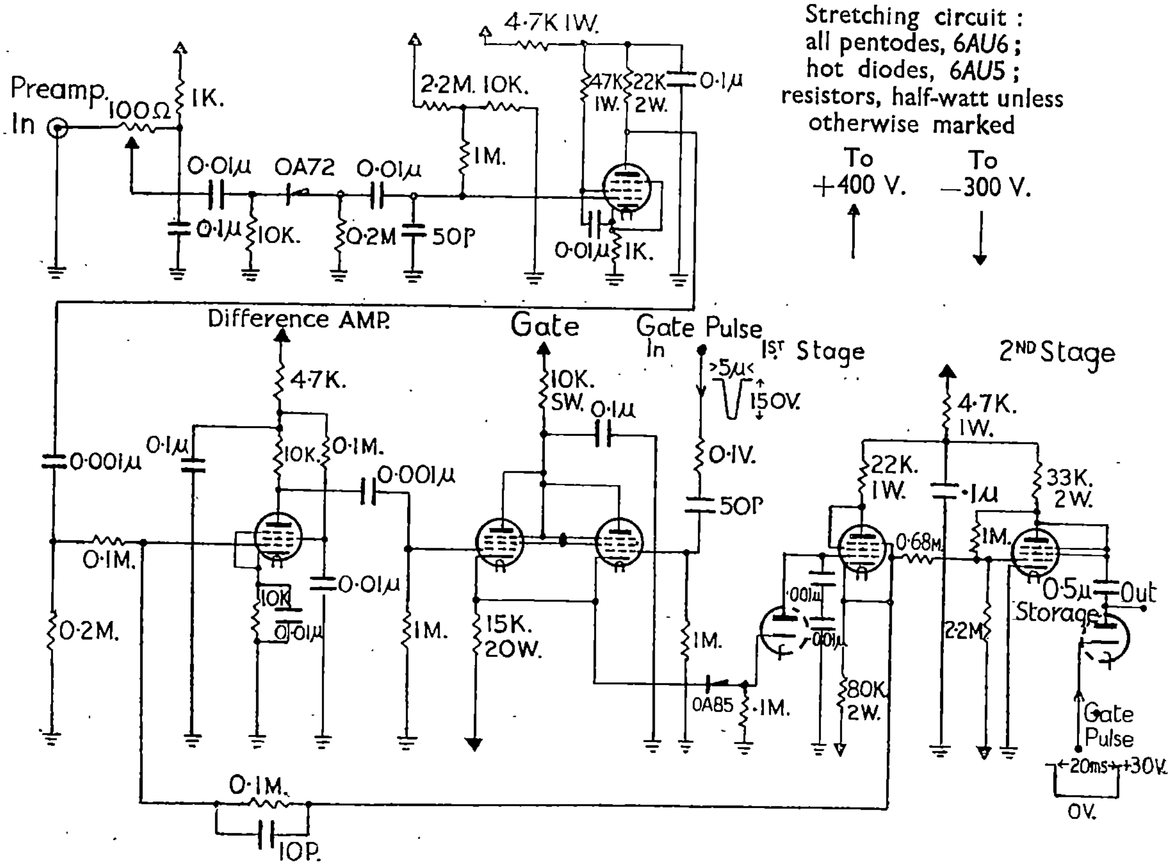

Fig. 2. Stretching circuit used for recording pulse-heights from scintillation counters

Recording the Results

The fast pulses carrying the time-of-arrival information are presented sequentially on the trace of a high-speed oscilloscope, which is photographed. A full description of the details and performance of this gear will be given in another paper.

The pulses carrying the density-of-particles information from the nine scintillation counters are pre-amplified and transmitted via coaxial cable to a central recording station. Here they are further amplified, and gated in coincidence with a master pulse generated whenever a shower triggers the recording gear. The details of the triggering system are described later. The resolution time of the gate is about 5 μsec. The gated pulses are then used to charge up condensers to voltages equal to the heights of the pulses. These condensers have a polystyrene dielectric, and will retain their charge for a period of hours without appreciable leakage. A diagram of the circuit used is given in Fig. 2.

The pulses produced by some of the associated equipment, for example, the multi-element Čerenkov detector and the unshielded Geiger tray, are stored in the same manner.

These stored voltage-levels are then converted one at a time into a binary number in the range 0–40. This covers a voltage range 0–60 V. by 1-V. steps in the range 0–20 V., and by 2-V. steps in the range 20–60 V. The gains of the circuits are arranged so that 1 V. corresponds to the mean pulse size caused by a single relativistic vertical μ-meson traversing the scintillation counter. This level of 1 V. is taken to represent one 'scintillator particle'[3]. The binary numbers thus formed are automatically punched out one at a time on standard 5-hole teleprinter tape. Also included on the tape are binary numbers representing the time of arrival of the shower as day of the week, hour and minute, and a serial number for the shower.

Some of the associated instruments, such as the penetrating-particle detector and the neutron-monitor register, give information directly in 'yes–no' form. This information is stored on thyratrons and punched sequentially on the tape.

The recording of the results from a single shower requires about 2 ft. of tape, and the automatic punching of this tape takes about five minutes. The output tape is allowed to accumulate for a day, during which some sixty or so events will have been recorded. The tape is then fed into the SILLIAC Digital Computer in the Adolph Basser Computing Laboratory for decoding and analysis. A simplified block diagram of the recording gear is given in Fig. 3.

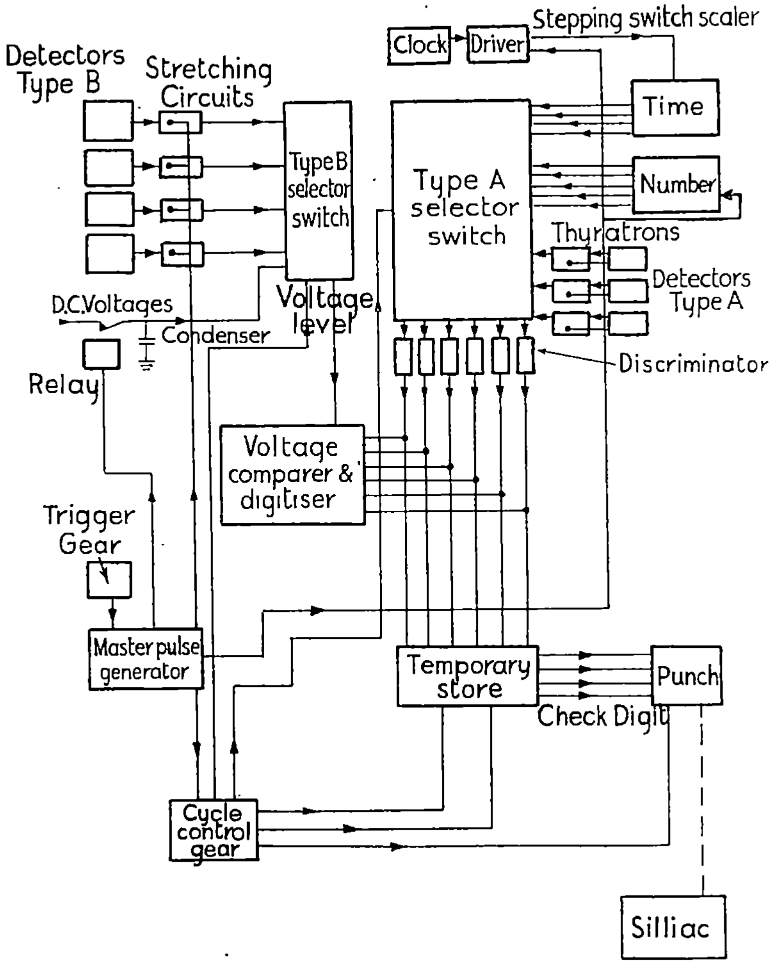

Fig. 3. Block diagram of recording gear

Analysis of the Data

The data tape is input to SILLIAC with a programme which converts recorded pulse-heights into numbers of particles traversing the detector according to the gains of the scintillation counters, which are measured daily by measuring the counting rate of pulses above the supposed 'one scintillator particle' level. An output tape is then obtained which, when printed on a teleprinter, gives a convenient visual presentation of the recorded events. No allowance is made in the programme for variations in the gain of the stretching circuits, which are set fortnightly, and remain constant within about 5 per cent. Also included on the output tape is the direction of arrival of the shower, as determined from the time delays. These delays are input via a manually punched tape.

This output tape contains the results from the various special detectors, besides the particle density information required to determine the core position and size of the shower. This additional information is carried without alteration through the next, and main, stage of the analysis, in which the core position and size are determined.

The analysis is carried out by fitting an assumed lateral structure function for the shower to the observed numbers of particles in the scintillation counters, and varying the assumed centre and total size of this structure function until the 'best' fit is obtained. It is assumed that the shower axis cuts the observation plane at a point (X, Y) and that the shower contains N electrons. We then expect to see a number m_i of electrons in a counter situated at $(x_i y_i)$, $(i = 1, 2 \ldots 9)$; where

$$m_i = N f_i$$

and

$$f_i = 0{\cdot}23 \frac{1}{2\pi} [\exp - r_i/75]/75(r_i + 1)$$

0·23 is the area of each counter in square metres, and r_i is the distance in metres from the counter to the shower axis, and is given by:

$$r_i^2 = (X - x_i)^2 + (Y - y_i)^2 - [l(X - x_i) + m(Y - y_i)]^2$$

where l and m are the direction cosines of the shower axis in the X and Y directions.

The form of the structure function, f, assumed by us is essentially identical with that used by the air shower group at the Massachusetts Institute of Technology[5]. However, we take a fixed characteristic radius of 75 m. and remove the singularity at the origin by using the divisor $75(r_i + 1)$ rather than $r_i r_0$.

We compute the probability that we would see a number of particles n_i when we expect to see a number m_i. The product of these probabilities (assumed to be Poissonian) for the nine counters is then the probability that a shower of the assumed type S characterized by X, Y and N would give rise to an event of the observed type E, characterized by $\{n_i\}$, and may be written $P(E/S)$. We fit the observed event by maximizing the posterior probability $P(S/E)$ that an event E was caused by a shower of type S, where:

$$P(S/E) = P(E/S)\, P(S)/P(E)$$

(The use of the posterior probability is discussed further in the appendix by one of us (C. S. W.).)

$P(S)$ is the *a priori* probability of occurrence of a shower of type S, taken to be proportional to $N^{-2{\cdot}5}$.

$P(E)$ is the *a priori* probability of recording an event of type E. Since $P(E)$ is independent of X, Y and N, it is neglected in the calculation.

We actually compute and minimize the function:

$$F(X,Y,N) = -\log_e (P(E/S) N^{-2{\cdot}5})$$

We take:

$$F(X,Y,N) = 2{\cdot}5 \log_e N + \sum_i [-\log_e (e^{-m_i} m_i^{n_i}/n\,!)]$$

Writing $m_i = N f_i$,

$$F(X,Y,N) = N \sum_i f_i - \sum_i n_i \log f_i - (\sum_i n_i - 2{\cdot}5) \log N + \sum_i \log n_i\,!$$

Since the recording system can deal only with numbers of particles up to 60, if $n_i = 60$, we use, instead of the probability of getting exactly 60 particles, the probability of getting 60 or more particles, that is

$$\sum_{n=60}^{\infty} (\exp - m_i)\, m_i^n/n\,!$$

We have tabulated $R(m_i)$ defined as:

$$-\log_e \sum_{n=60} (\exp - m_i)\, m_i^n/n\,!$$

for $m_i = 0, 1, \ldots 80$.

Reserving the subscript i for unsaturated counters $(n_i < 60)$ and using j for saturated counters, we have:

$$F(X,Y,N) = N\sum_i f_i - \sum_i n_i \log f_i - (\sum_i n_i - 2{\cdot}5) \log N + \sum_j R\,(N f_j) + \sum_i \log n_i\,!$$

To find the values of X, Y, N leading to a minimum for $F(X,Y,N)$, we first define $F_0(X,Y)$ as the minimum value of $F(X,Y,N)$ obtained for fixed X, Y by varying N. When there are no saturated counters, the value $N_0(X,Y)$ for N which gives this minimum is simply:

$$N_0 = [(\sum_i n_i) - 2{\cdot}5]/\sum_i f_i$$

Where one or more counters are saturated, we first compute a series of approximations to N_0, which are:

$$\frac{\Sigma n_i - 2{\cdot}5}{\Sigma f_i}, \frac{\Sigma n_i - 2{\cdot}5 + 60}{\Sigma f_i + f_a}, \frac{\Sigma n_i - 2{\cdot}5 + 120}{\Sigma f_i + f_a + f_b}, \ldots,$$

where $f_a, f_b, \ldots$ are $\{f_j\}$ arranged in increasing order of magnitude. In doing so we are in effect ignoring first all saturated counters, then all but the one with the least expected number, then all but the two with the least expected numbers, etc.

The largest of these approximations, which must all be less than N_0, is used as the starting value for a Newton's method approximation to the solution of the equation:

$$\frac{\partial}{\partial N} F\,(X, Y, N) = 0$$

The solution of this equation is obtained to about 1 per cent accuracy.

The minimum value of $F_0(X,Y)$ is then found by varying X and Y by a method of steepest descent, taking as initial values for X and Y the co-ordinates of the counter having the largest value of n_i. The best values X_0, Y_0, N_0 (X_0, Y_0) are then printed, together with $F(X_0, Y_0, N_0)$ and estimates of the positive and negative errors in X, Y and N.

These errors are based on the sharpness of the minimum of $F_0(X,Y)$, and are such that the range of values for X, Y and N specified by these errors includes all sets of values (X_1, Y_1, N_1) in the neighbourhood of (X_0, Y_0, N_0) which are more than one-eighth as probable as (X_0, Y_0, N_0). The finite width of the minimum about $F_0(X,Y)$ with variation of N is neglected, as it is always much smaller than the errors in N defined above. Other calculations referred to below have shown that values of X, Y and N in the ranges specified usually contribute at least 90 per cent of the total contribution to the integral:

$$\int_{-\infty}^{\infty} dx \int_{-\infty}^{\infty} dy \int_{0}^{\infty} dN\, P(S/E)$$

To give a convenient measure of how well this calculated shower fits the observed event, we also compute and print a quantity χ^2 defined by:

$$(s - 3)\chi^2 = [\sum_i (n_i - m_i)^2/n_i]_{0 < n_i < 60} + 2[\sum_i m_i]_{n_i = 0} + [\sum_j 60/m_j]_{n_j \geqslant 60}$$

where s is the number of counters in use, and m_i, m_j are calculated from X_0, Y_0, N_0. The quantity χ^2 is

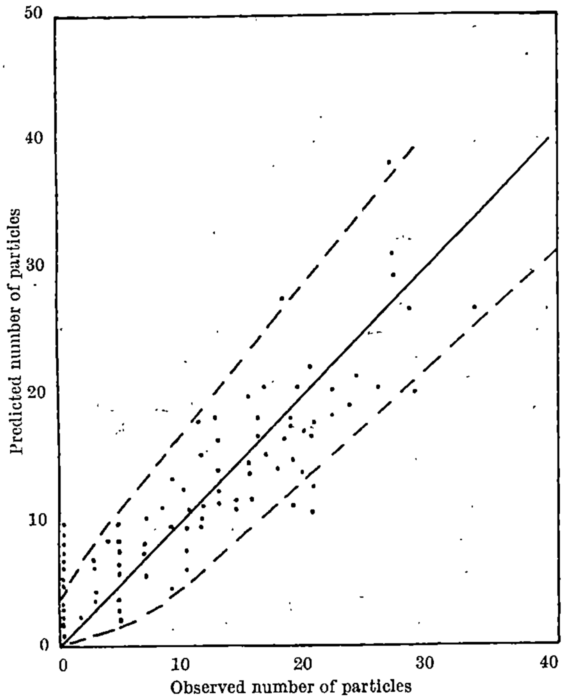

Fig. 4. Scatter diagram showing correlation between predicted and observed numbers of particles in a scintillation counter in the air-shower array. The co-ordinates of each point show the predicted and observed numbers for one shower. The dotted lines represent the 10 per cent limits of a Poissonian distribution

a more convenient measure of fit than $F(X_0Y_0N_0)$ for purposes of comparison with other events, because it has an expectation value of approximately one.

The complete analysis process described above takes about 45 sec. per event.

Accuracy of System

The gains of the scintillation counters are fixed by daily adjustment to an accuracy of about 5 per cent. The pulse storage and digital conversion circuits are calibrated to 5 per cent fortnightly. We therefore expect the particle density measurements to be limited to about 10 per cent accuracy by the instrumentation. This is, however, smaller than the expected Poissonian fluctuations in the measured density. Since we were not sure what effect these fluctuations and instrumental errors would have on the determination of the core position and size of the showers, the following check was carried out: a typical batch of events was analysed as if one of the scintillation counters were unserviceable, that is, the observed number of particles in it was not used in analysing the events. Then, the expected number of particles through this counter was computed from the estimated core position and shower size, and compared with the observed number. The results of this comparison are shown in Fig. 4. It can be seen that the agreement is in general within the expected statistical fluctuations.

The 'errors' in core location and shower size estimated by the analysis programme (see earlier) vary widely from shower to shower. For a shower of size 10^6 particles falling inside the array, the location errors are normally about 5 m., and the errors in size about 20 per cent in the positive direction and 10 per cent in the negative direction.

Separate calculations (discussed in the appendix have been made to obtain the probability distribution for N independently of X and Y. These distributions normally have a peak at a value of N about 5 per cent greater than N_0, and are quite skew, having a median value about 15 per cent greater than N_0. This skewness increases when the showers fall outside the array.

Similarly, for 10^6 particle showers falling within the array, the probability distribution of (X,Y) independently of N has 90 per cent of its total probability within 5 m. of (X_0,Y_0); but when the shower falls outside the array, the distribution has a tail extending away from the array, and the core location errors for such showers, and for small showers within the array, may frequently be 15 or 20 m.

Lateral Structure Function

While this array was not designed to investigate the lateral structure of showers, we have obtained from our results an average structure function for showers of sizes in the range 10^5–10^7 particles, mainly as a check on the validity of the function which we, together with the Massachusetts Institute of Technology group, assume in our calculations, namely:

$$\rho(r) = \frac{N}{2\pi}\,\frac{\exp(-r/r_0)}{r/r_0}$$

Although our observed distribution is based on a method of core location which assumes a lateral distribution, we have found that the core location of showers, for showers falling inside the array, is not very sensitive to the assumed distribution.

The distribution obtained is shown in Fig. 5, together with the above function and the theoretical distributions of Moliere and Nishimura and Kamata.

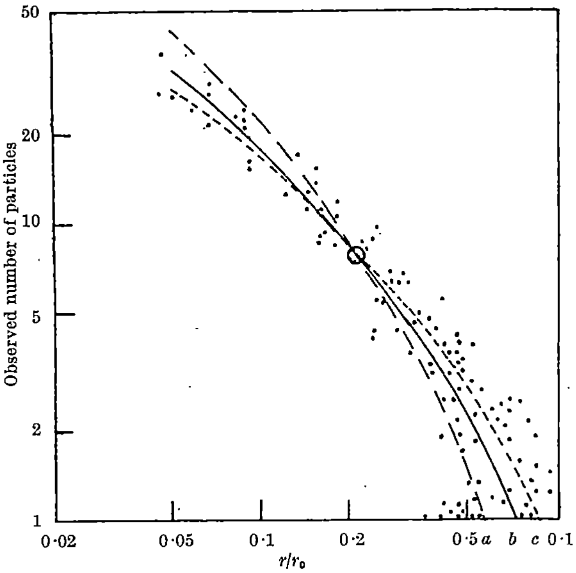

Fig. 5. Scatter diagram showing observed lateral structure function. The co-ordinates of each point represent the distance of a counter from the core of a shower, and the observed number of particles in the counter, normalized to a shower size of 3×10^6 particles. Points are plotted for every counter for 15 showers of sizes in the range 3×10^5 to 10^6 particles. Curve b is the structure function used in our analysis, curve a is the Moliere distribution and curve c is the Nishimura and Kamata distribution for $s = 1{\cdot}4$. Curve b is for a shower size 3×10^6 particles. The other two are normalized to it at the circled point

It can be seen that the agreement with our assumed function is quite good.

As has been found by other workers, the Nishimura and Kamata curve for $s = 1{\cdot}4$ fits the observed distribution very well, but there is a marked disagreement with the Moliere distribution.

Observed Rate of Air Showers

Because this array is primarily intended for the study of individual showers, the arrangements for triggering the recording gear have been designed to give the maximum rate of events likely to give a useful response in the special instruments attached to the array. The array may be triggered either by a four-fold coincidence of one or more particles in each of scintillation counters 2, 3, 8 and 9, or by a three-fold coincidence of more than five Geiger counters firing in each of three trays of 10 counters placed near the cloud chamber (Fig. 1). The area of each counter is 0·02 sq. m. Furthermore, no event is analysed unless at least three of the nine scintillation counters have recorded at least two particles, and no event is analysed if more than six of the nine counters are saturated.

Thus the question of what percentage of showers of various sizes falling in various positions will trigger the array and ultimately be analysed would be very difficult to answer, and we have made no attempt to do so. We therefore cannot obtain information about the rate of occurrence of showers from the majority of our recorded events, and so the rates we have determined have been based on rather poor statistics. However, we have calculated that any shower of size greater than 3×10^5 particles falling inside an area 20 m. × 28 m. centred within the area bounded by three triggering scintillators (at a time when the fourth was not in use) has a probability greater than 95 per cent of triggering the array. During a run of total sensitive time 115 hr., during which the Geiger-tray triggering was disconnected, some 59 showers of size greater than 3×10^5 particles fell in this area. The rate of showers of various sizes was consistent with an integral size spectrum given by:

$$K(> N) = 4{\cdot}5 \times 10^{-8} (N/10^6)^{-1{\cdot}6 \pm 0{\cdot}1} \text{ m.}^{-2} \text{ sec.}^{-1}$$

A further run using all four triggering scintillators in four-fold coincidence was made. Because of the more stringent triggering requirements, the collecting area for a probability of more than 95 per cent triggering was reduced to 13 m. × 16 m. for showers of size greater than 4×10^5 particles. Since this area was too small to yield many large showers, a further area (enclosing the first) of 25 m. × 31 m. was used for showers larger than 7×10^5 particles. Thirty-four showers were recorded in a sensitive time of 87 hr. The results from this run, when combined with the previous results, give a spectrum:

$$K(> N) = (4{\cdot}0 \pm 0{\cdot}5) \times 10^{-8} (N/10^6)^{-1{\cdot}7 \pm 0{\cdot}1} \text{ m.}^{-2} \text{ sec.}^{-1}$$

This spectrum is in substantial agreement with that obtained by other workers.

The sizes of the showers have been corrected in this to the sizes which would have been obtained by using Geiger counter detectors rather than scintillation counters. The details of this correction will be discussed in a later article.

Summary

The detecting array which has been described, together with the analysis of the observations based on the maximum likelihood method, provides a system for detecting and analysing air showers of size in the range 10^5–10^7 particles. The cores of such showers falling within the array may be located with an accuracy of ± 5 m., at a probability-level of 90 per cent, and their sizes determined within limits of + 20 and − 10 per cent at the same probability-level. If it were desired to increase the accuracy of these determinations, then it would be necessary to increase the areas of individual detectors so that the percentage fluctuations in numbers of particles traversing the counters might be reduced. It would be necessary at the same time to increase the accuracy of recording these numbers in order to keep instrumental uncertainties below the level of these reduced statistical fluctuations. In the same way, obviously, an increase in the number of detectors in use would also improve the accuracy of the system, but so far no quantitative estimate of the importance of these factors has been investigated.

With the existing arrangement a number of checks on the performance have been possible. Such a check is provided by the comparison between the predicted and the observed densities of particles at the position of one of the detectors, while others are afforded by the agreement between the shower structure function and the shower size spectrum as here reported and the determinations of these by other workers.

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Appendix: Use of the Posterior Probability Distribution

If we followed the normal procedure of maximum likelihood analysis[6], we would choose those values of X, Y and N which jointly maximized $P(E/S)$. The result (for events in which no counter was saturated) would be very nearly the same as that obtained by maximizing χ^2, since in this case the difference between $\log P(S/E)$ and $(s - 3)\chi^2$ involves only terms of order $m_i^{-1/2}$ and smaller, and terms independent of S. However, analysis along these lines is liable to systematic bias as shown below. Moreover, as some objection to the use of the posterior probability distribution appears in the literature[7], we consider that some justification for its use is required.

Suppose that all showers could be divided into five types denoted S_1, S_2, S_3, S_4 and S_5, and that these different types of showers occurred with relative frequencies $10^4 : 10^3 : 10^2 : 10 : 1$. Suppose, further, that these showers caused events of five types E_1, E_2, E_3, E_4 and E_5 with probabilities as shown in Table 1.

Table 1. VALUES OF $P(E/S)$, THE PROBABILITY THAT AN EVENT OF TYPE E IS PRODUCED BY A SHOWER OF TYPE S

	S_1	S_2	S_3	S_4	S_5
E_1	0·8	0·1	0	0	0
E_2	0·2	0·8	0·1	0	0
E_3	0	0·1	0·8	0·1	0
E_4	0	0	0·1	0·8	0·2
E_5	0	0	0	0·1	0·8

Then according to the standard theory of maximum likelihood, one would ascribe an event E_1 to a shower of type S_1, an E_2 to an S_2, and so on, and would say that in this description each shower had an 80 per cent chance of being correctly typed. If now we convert the above probability distribution into the corresponding frequency distribution, we obtain the following (Table 2):

Table 2. FREQUENCY DISTRIBUTION DERIVED FROM TABLE 1

	S_1	S_2	S_3	S_4	S_5
E_1	80,000	1,000	0	0	0
E_2	20,000	8,000	100	0	0
E_3	0	1,000	800	10	0
E_4	0	0	100	80	2
E_5	0	0	0	10	8

It will be seen that, while the most probable cause of an event of type E_1 is still a shower of type S_1, the most probable cause of an event E_2 is again a shower of type S_1, not S_2. Again, the normal maximum likelihood method would ascribe an event E_3 to a shower S_3 and claim 80 per cent probability of being correct. It will be observed, however, that of all the events of type E_3 recorded, only 44 per cent are produced by S_3 showers; the majority of them are, in fact, produced by S_2 showers.

The chances of correct assignment for E_1 events, which we may reasonably identify with events failing to trigger the apparatus, is 98·8 per cent, but the chances of correct assignment for all other types of events averages only 30 per cent. Thus, if, as is certainly the case, a very numerous class of small showers has a low triggering probability, the frequency of success of the standard method in analysing observed events drops from 80 to 30 per cent.

It will be seen, therefore, that if some classes of showers are vastly more numerous than others, as is the case, and if the probability distribution $P(E/S)$, the probability that an S-type shower will produce an E-type event, is not sharply peaked, then some account must be taken of the *a priori* probability of occurrence of the S-type shower, $P(S)$, in order to avoid a consistent over-estimate of the shower size. This has been done in the analysis of the air shower data by using Bayes's Theorem[6]:

$$P(S/E) = P(E/S)\,P(S)/P(E)$$

The quantity $P(S/E)$ can be meaningfully interpreted only as a relative frequency of the type discussed above. Such an interpretation is not strictly admissible in our case, since we would very rarely indeed see even two events of the same type. However, investigation of the form of the function $P(S/E)$ as a function of S for various different events E has shown that large numbers of events are sufficiently similar to justify the use of this quantity.

It should also be pointed out that we cannot claim freedom from bias in the determination of any quantity which we may wish to estimate about a shower using the analysis programme described. If, for each shower, we had been concerned to find the most probable value of N, the shower size, without at the same time requiring to know the core location, then we should maximize $P(N/E)$ defined as:

$$P(N/E) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} P(S/E)\,dX\,dY$$

This has, in fact, been done by us for a sample of showers as has been mentioned, and the best value of N so determined is, in general, greater by about 5 per cent than is the value computed in the normal analysis. One should, in fact, maximize the probability distribution of whatever single physical result is desired such as shower size, core location, density of particles at a particular detector, and so on. Such a course is, however, impracticable because of the volume of computation involved. The calculations mentioned above for finding the most probable value of N independent of the core location (X, Y), and for finding the probability distribution in the core location consumed some 10–50 min. of machine time per event analysed.

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LIFE AT LOW TEMPERATURES

IN recent decades man has been striving for mastery of chemical, physical and climatic forces, however abstruse or remote from his usual environment. Such mastery, when achieved, would be ineffectual or even dangerous if the biological effects of the same forces had been ignored, either in their impacts on individual plants and animals or in their widest ecological significance. During the past year, temperatures lower than any hitherto recorded in the range below 1° K. have been produced by adiabatic demagnetization and their effects on the properties of matter have been studied. During the same period, Antarctica has been crossed above and the North Pole below its ice cap. It was therefore appropriate that the British Association should hold a joint session of Sections D and I (Zoology and Physiology) on August 28 to discuss life at low temperatures.

Dr. K. Mellanby emphasized that insects of a large group are killed at temperatures above freezing point and become comatose from cold before there is danger of death. Self-protective responses and development are inhibited when their surroundings are comparatively warm. Many insects would be incapable both of completing their life-cycles and of avoiding extermination unless the environmental temperatures were well above zero for a considerable period each year. Such insects become rapidly acclimatized by brief exposure to a slightly colder environment. Thus, the chill-coma temperature of cockroaches kept at 30° C. is 7·5° C., but when individuals from the same stock are kept at 15° C. for as little as 24 hr. they afterwards move actively at 2° C. Similarly, the alarm reaction of larvæ of the yellow fever mosquito (*Aedes aegypti*) can be elicited at lower temperatures after exposing them for 24 hr. to colder water. The processes of acclimatization in insects are rapidly reversible, and their underlying mechanism remains a mystery. Insects of a second large group survive exposure to temperatures below freezing point provided that they remain supercooled. Crystallization of ice in their tissues is fatal to them. The degree to which they can be supercooled depends on the duration of exposure to that temperature. It also depends on the water content of the tissues and of the material in the gut. No material exists more water-proof than insect cuticle. Nevertheless, when a drop of moisture freezes on the outer surface of a supercooled insect the tissue fluids beneath the cuticle are instantly inoculated with ice and freeze. Recently, Asahina and Aoki[1] reported that certain moth larvæ survived freezing in liquid air under conditions in which the greater part of their body-water was converted into crystals of ice situated outside the individual cells composing the tissues. Dr. Mellanby pointed out that, from an ecological point of view, liquid air is not an important habitat. On the other hand, witnesses of the advent of spring in the Arctic describe the abundance of active insects before the snow has melted sufficiently to uncover sheltered spots with warmer micro-climates[2]. The third group of insects which survive freezing at low temperatures may, therefore, be larger and more important than hitherto supposed.

Rome and Cape Cod are at approximately the same latitude (42°). It was therefore surprising to learn from Dr. J. W. Kanwisher that temperatures between − 15° and − 30° C. are frequently recorded on the shore at Woods Hole in winter. The intertidal molluscs are in open air for 6 hr. or more around low tide twice each day. When not covered by sea water the internal temperatures of oysters, mussels and periwinkles are almost identical with the atmospheric temperature. At − 15° C., 60–85 per cent of the water in the bodies of these molluscs was frozen. Nevertheless, intact molluscs of the same species recovered fully when thawed after freezing to the same extent. Histological sections of tissues from the frozen animals showed remarkable distortion of the muscles and of the internal organs by ice crystals situated outside the cells which were shrunken. Within a few seconds of thawing the microscopic anatomy was normal. When water crystallized as ice the tissues were exposed to increased salinity, reaching a maximum at − 20° C. The tissues of the intertidal molluscs became isosmotic with concentrated solutions of salt to which they were exposed experimentally. A change in temperature of 10 deg. C. altered their oxygen consumption by a factor of 2 in the range above 0° C. and by 50 below 0° C. An increase in the salt concentration above zero equivalent to the increased salinity of partially frozen sea water cooled by 10 deg. C. reduced the oxygen consumption of the molluscs by a factor between 10 and 20. The striking alteration in the $Q_{10}(O_2)$ of the frozen animals cannot, therefore, be entirely explained by the combined effects of raised salinity and reduced temperature. Decreased diffusion of gases and increased viscosity of residual tissue fluids may also be involved. Many molluscs are immobile at 0° C. Some teleost fish, on the other hand, swim in Arctic waters at a temperature which remains steadily at −1·7° C. at the bottom and fluctuates near the surface between −1·7° C. below the ice in winter and +7° C. after the ice has melted in summer. The freezing point of blood from teleosts in temperate waters is between −0·5° C. and − 0·8° C. The freezing point of plasma from five species of deep-water Arctic fish was between − 0·9° and − 1·0° C. These fish were actively swimming with their tissue fluids in the supercooled state. They were in no danger of being seeded with ice crystals in their own ecological niche, but when brought near the surface on which ice was floating they soon froze throughout and perished. By contrast, the plasma of the Arctic surface fish froze at − 0·8° C. in summer and at − 1·5° C. in winter. The osmotic concentration of their body fluids had doubled before winter set in, so that they became supercooled by less than 0·4 deg. C. The risk of freezing was thus reduced when ice formed nearby. Dr. Kanwisher's demonstration that animals can retain full activity in the supercooled state has introduced a new conception into low-temperature ecology.

The practice of storing semen in the frozen state at low temperatures is no longer new. Nine years have passed since the report was published that glycerol protected avian spermatozoa against damage during freezing and thawing[3]. Seven years ago the possibility of banking glycerol-treated frozen bull semen was discussed at the British Association. Since then the technique has been adopted at every major cattle-breeding centre where artificial insemination is practised. A review by Dr. C. Polge, the leading authority on the subject, was therefore welcome. He said that it was essential to restore the motility of a high proportion of spermatozoa in semen to be inseminated after freezing to and storage at low temperatures. Dilution to contain a suitable concentration of glycerol and a slow rate of cooling are the two procedures vital for preserving sperm from most mammals. Human spermatozoa are exceptional. Some survive when ampoules containing untreated semen are frozen rapidly by immersion in liquid nitrogen at − 196° C. Spermatozoa of the bull and other mammals are killed by rapid cooling either above or below zero. Physico-chemical changes in the cell membrane may be responsible. Ultra-rapid cooling might cause instantaneous formation of minute intra- and extra-cellular ice crystals. Slow cooling results in growth outside the cells of larger crystals which might be less destructive; simultaneously, however, the concentration of salts rises and the spermatozoa are pickled in strong brine. Glycerol buffers the salts during freezing and permits slow cooling to avoid thermal shock. Other neutral solutes act similarly, but glycerol is unique in its lack of toxicity in high concentrations at low temperatures. The optimum initial concentration of glycerol is approximately 10 per cent for protecting bull spermatozoa, but varies for sperm of other species according to their electrolyte sensitivity and is 0–5 per cent in human and 30 per cent in rabbit semen. The motility of glycerol-treated spermatozoa of ram, boar and rabbit is high after freezing, but the fertility of the thawed semen, assessed by artificial insemination, has so far been reduced or abolished in these species. Human pregnancies have been reported in the United States following insemination of glycerol-treated frozen semen[4], but no critical experiment has been or is likely to be carried out in Great Britain. The fertilizing capacity of bull semen is not impaired by addition of glycerol and prolonged storage at – 79° or –196° C., as judged by the proportion of cows which become pregnant and the millions of normal calves already born as the result of its use. Semen of the 1952 Cambridge vintage, including samples from a bull now dead three years, still show little, if any, reduction of activity or fertilizing capacity. Farmers are already exploiting a wide choice of bulls not previously at their service. When results of progeny tests on young bulls are obtained, large stocks of semen from the best sires will be available locally and for export. Great improvements in cattle are anticipated throughout the world. Eventually, perhaps, the technique will be applicable to other farm animals.

A wide variety of other mammalian cells and tissues can now be frozen and stored without loss of viability in media containing glycerol at low temperatures. The story of how bone marrow came to be preserved in this way was told by Dr. D. W. H. Barnes. The starting-point was Jacobson's discovery in 1950[5] that mice could be saved from death after lethal doses of X-rays if, afterwards, fragments of infantile mouse spleen were inserted intraperitoneally. The explanations proposed were either that a chemical agent from spleen protected tissues sensitive to irradiation or that hæmopoietic cells from the implanted tissue repopulated the bone marrow, which would have been totally destroyed by the doses given. The report by Lorenz[6] that marrow from guinea pigs would protect mice of certain strains boosted the humoral theory. However, Barnes and Loutit had evidence that any treatment which killed the splenic cells also abolished their protective effect. One such treatment unlikely to harm a chemical agent was storage at + 4° or at – 15° C. Splenic tissue was therefore treated with glycerol and cooled to – 79° C. by the method used for preserving the viability of ovarian tissue. When the material was thawed and injected into mice after irradiating them with the lethal dose of 950 r., the proportion of survivors was as high as in the control group treated with fresh spleen. There was no loss in potency of tissue after 83 days at – 79° C. Rat bone marrow was then found to be effective in treating irradiated mice, and Barnes observed an early regeneration of hæmopoietic tissue. There are distinctive differences between the chromosomes of the mouse and the rat, which enabled Ford and Hamerton to demonstrate large numbers of dividing rat cells in the marrow, spleen and lymph glands of the treated mice[7]. Radiation had destroyed the ability of the animals to react against the foreign cells which had therefore colonized the damaged hæmo- and lympho-poietic tissues. These mice also accepted grafts of rat skin, which survived indefinitely and were recognized by the colour and length of the hairs. Rat bone marrow which had been stored in the frozen state gave results as good as those obtained with fresh marrow.

Hitherto, the concept of animals composed of tissues from two or more species has belonged to mythology. The modern chimæra, produced after irradiation, is a brilliant departure from conventional biology. It is gratifying that the use of low temperatures should have contributed to its recognition. Hopes can now be renewed of establishing banks of frozen but viable bone marrow and other tissues to replace deficient or disordered tissues in man.

Re-animation of dead and frozen animals and man is another concept with origins in antiquity. Claims to have witnessed or effected such resurrections have been made and refuted many times in ancient, medieval and modern times. Superficial tissues can be frozen without altering the internal temperature or endangering the life of the animal as a whole, although frostbite may cause local death and loss of extremities. Man and other mammals become anæsthetized when cooled by as little as 10–15 deg. C. Claude Bernard showed that guinea pigs recovered when rewarmed from internal temperatures of 18°, but at 16° C. breathing and heart beats stopped and they died. Cooling to approximately this degree was lethal to all non-hibernators. The demonstration by Andjus[8] that rats could be resuscitated from body temperatures between 0° and 2° C. and after 1 hr. of respiratory and circulatory arrest necessitated revision of criteria of death and opened new possibilities for therapeutics and experimentation. Dr. A. U. Smith has cooled golden hamsters until breathing and heart beats were at a standstill and then immersed them in baths at – 5° C. to reduce the deep body temperature below zero. About 75 per cent of the animals froze progressively while the deep body temperature remained at the freezing point of plasma (– 0·6° C.). At the end of an hour the proportion of water converted to ice was 90 per cent in the subcutaneous tissues, 60 per cent in the brain and 50 per cent in the entire body. Nevertheless, hamsters frozen for periods up to 1 hr. recovered fully after rewarming the whole body with diathermy and giving artificial respiration. Frost-bite only occurred if the extremities had been bent in the frozen state. About 25 per cent of the hamsters became supercooled and were resuscitated completely from body temperatures as low as –5·0 C. Those which crystallized spontaneously after supercooling to temperatures below – 3·0° C. did not revive. Difficulties arose when rabbits and small primates (*Galago crassicaudatus*) were frozen at and rewarmed from body temperatures below 0° C. Heart beats, breathing and spontaneous movements were usually regained after thawing, but the animals died a few hours later, showing that present techniques are inadequate. Experiments on freezing isolated uteri and hearts suggest that eventually it may be possible to perfuse the whole mammal with glycerol and revive it after freezing at temperatures as low as those used for storing isolated cells and tissues. Much remains to be done before these results could be applied to man.

It was remarkable that this symposium should have assembled so much information not discussed at recent conferences on low-temperature biology[9,10]. Many new problems were also posed, some of which, it is hoped, will be solved by scientists of other disciplines and of the rising generation who had gathered at the British Association's meeting in Glasgow.

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APPLICATIONS OF CRYSTALLOGRAPHY TO CHEMISTRY

SECTION B (Chemistry) of the British Association on August 29 devoted a morning session of the annual meeting held in Glasgow to a discussion of the chemical applications of modern crystallography. The meeting was well attended and three papers were presented dealing, respectively, with applications to organic chemistry, inorganic chemistry, and with the packing of molecules in crystals.

In his paper on "The Measurement of Molecules by X-Rays" Prof. J. Monteath Robertson first outlined the classical methods and concepts of organic chemistry by means of which the relative positions in space of all the atoms in many hundreds of thousands of organic molecules have been determined, starting with the fundamental ideas of Kekulé and Archibald Scott Couper of Kirkintilloch. In contrast, the X-ray crystallographic method, developed during the past forty-six years, proceeds by direct measurement and calculation from the diffraction pattern. Kekulé's formula for benzene was shown and compared with the latest electron density section evaluated in the plane of the molecule by Prof. E. G. Cox[1]. This shows a time average of the distribution of electrons, and the atoms stand out as peaks on the contoured diagram. The main cause of the blurring of the atoms in this diagram is the fairly large amplitude of thermal movement that they possess in the crystal even at −3° C., the temperature at which the measurements were made. The motion is mainly an oscillation of the whole molecule of amplitude 7–9 deg. about the six-fold axis.

Similar sections of the naphthalene and anthracene molecules were shown, based on a very complete evaluation of the X-ray intensity data[2]. These crystals have higher melting points than benzene, and the thermal movements of the atoms, although still large, are less than in benzene. The definition of the atoms is now so good that the bond-lengths can be estimated to within a few thousandths of an angstrom.

Further elaborate refinements have recently been carried out on these molecules to try to obtain evidence regarding the distribution of the electrons that form the chemical bonds between the atoms. Briefly, the method consists of calculating the theoretical distribution of electrons in an isolated or non-bonded carbon atom. The thermal movement, which smears out the electron distribution, is then carefully calculated from the X-ray intensities. The theoretical atoms, each with its proper thermal movement but non-bonded, are then subtracted from the experimentally observed electron distributions. Any residual electron density may then be attributed to the effect of the chemical bonds. At this limit of refinement the accuracy of the observations (the measured intensities) is not sufficient to yield really conclusive results. But the results which have recently been obtained by D. W. J. Cruickshank[3] provide fairly definite experimental evidence for a ridge of residual density running around the aromatic rings and along the directions of the chemical bonds. This is in striking agreement with chemical theory for aromatic systems.

In addition to this work on simple molecules, a second and most important application of the X-ray diffraction method is in dealing with new, chemically unknown or incompletely known structures, where the object of the work is not so much extreme accuracy as just to locate the atoms in order to discover the structural formula. Serious problems of phase determination now arise, and the most generally successful method has been the use of a single atom or small group of atoms somewhat heavier, or containing more electrons, than the atoms of the unknown carbon–hydrogen skeleton of the molecule. The method was illustrated in a simple form in the structure determination of nickel phthalocyanine[4].

With the compounds of organic chemistry it is generally fairly easy to insert a marker atom without unduly disturbing the structure. Halogen atoms may often be attached, or if the compound is an acid then heavy metal salts may be prepared. It is probably true to say that this general method has been utilized, in some form or another, in the great majority of X-ray structure determinations of complex organic compounds during the past twenty years. The list of successful determinations is now so large that it would be tedious to try to enumerate them all. The structures of many natural products in the terpene and alkaloid fields, and several important antibiotics, have been determined in this way.

To begin with, the results have generally confirmed and put on an exact metrical scale what the chemist already knew, in outline at least. But as the technique of the subject advances the solution of chemically unknown structures is becoming more feasible. Already some notable contributions have been made. In the terpene field the structures of longifolene[5], lanostenol[6], and oleanolic acid[7] have been solved. The structure of the alkaloid isocryptopleurine was solved by Fridrichsons and Mathieson[8] without any chemical data except the empirical formula, and the tropolone derivative nootkatin[9] was recently solved in Glasgow.

Much the most striking recent result in this field, however, is the solution of the structure of vitamin B_{12} by Dorothy Crowfoot Hodgkin, John White and their many collaborators[10]. When this work began in 1948 there was no information about the chemical nature of the vitamin. But during the next eight years the chemical structure of various groups within the molecule was determined. A nucleotide-like group consisting of a benziminazole ribose phosphate, a propanolamine residue and various amide groups were discovered. There was also a cyanide group and, most important, a large fragment containing cobalt which it was suspected might be a porphyrin-like nucleus. There was, however, no very direct chemical evidence as to how all these groups might be linked together.

The presence of the cobalt-containing fragment and the possibility of a nearly planar porphyrin group (the crystals are strongly pleochroic) stimulated the X-ray work. If a structure is not too complex, the presence of a single atom like cobalt, favourably situated, may sometimes lead to a very complete structure determination. But vitamin B_{12} is vastly more complex than the compounds we have been considering, and with phases based on the cobalt contribution the density maps were very blurred and confused.

At this stage help was obtained from a study of the various other compounds that had been prepared by the chemists. In addition to the wet and air-dried vitamin, two other compounds proved to be most useful. These were the seleno-cyanate derivative, $B_{12}SeCN$, with a second heavy atom, and most important of all, a hexacarboxylic acid obtained by degradation (alkaline hydrolysis) which contained the porphyrin nucleus and its side chains. This crystalline fragment, obtained by Todd and his co-workers, was much less complex than the full vitamin ($C_{46}H_{58}O_{13}N_6CoCl$ instead of $C_{63}H_{88}O_{14}N_{14}PCo$, but these formulæ were not established until later). Even this fragment, however, still represented an excessively complex structure determination.

The general method of attack was now to pursue all these structure determinations simultaneously. When some atoms or groups of atoms became fairly definite, and were confirmed by their appearance in the maps obtained from the other derivatives, then those atoms were inserted in the phasing calculations in gradually increasing numbers, which resulted in diagrams of increasing clarity and definition. The process of gradually deducing the structure by successive approximations is not, however, such a straightforward and easy task as it may sound. If a false atom is inserted in the phasing calculations it will appear in the place where it is put. But if false it will generally cause a peak of less than the expected height and be more poorly defined than would be the case with a genuine atom correctly placed. The work requires much judgment and intuition, and a continual process of checking against what is plausible on chemical grounds.

Another difficulty in this work, of course, is the tremendous amount of numerical calculation required. Each stage involves the evaluation of a triple Fourier series of several thousand terms at many tens of thousands of points throughout the unit cell. It is essentially a job for the large electronic computers; and the later stages of the work owed much to Dr. Trueblood and the computer SWAC at Los Angeles.

In the latest work the positions of all the atoms in the molecule and of about 12 out of an estimated 24 molecules of water in the wet crystal have been ascertained. This very precise and beautifully determined structure should now form a basis for the better understanding of the biological activity of the vitamin, its relationship to the porphyrins and to porphobilinogen, and may also perhaps lead to its ultimate chemical synthesis.

This example was described at some length because it illustrates better than any other the enormous power of the X-ray method of analysis when applied to the solution of complex structures. When we remember the steady advances in technique which are taking place, and in particular the design of faster and more efficient electronic computers, we begin to realize what the effect of this new method on the future progress of chemistry is going to be. In determining the positions of atoms in space, which is to a large extent the basis of chemical knowledge, we have certainly moved a long way from those first fumbling steps which were taken about a century ago.

In the next paper, by Peter Pauling, on "A Rebirth of Inorganic Crystallography", a very brief review of the progress of X-ray analysis in the inorganic field was given. The early structural data, the Bohr atom and the new quantum mechanics allowed a theory of inorganic chemical bonding to be developed which extended the co-ordination theory of Werner and the covalent bond of Lewis. This went well on the way toward giving inorganic chemistry a unified theory, but it is certainly not complete. The post-war ligand field theory has had good success in explaining certain spectral phenomena and structural anomalies, but it is still not complete, as crystallographers and chemists have shown.

The impact of these theories has caused a renewed interest in inorganic chemistry and the structures of inorganic compounds. Inorganic chemistry still does not have a unified theory, though a means of thought and a direction in which to go are known, and it is certain that a complete theory will contain most important terms based on the spatial arrangement of the atoms as determined and checked by diffraction techniques.

In the last paper, on "How Molecules Fit Together", H. M. Powell said the fact that molecules fit together at all may seem remote from social significance, but an audience is itself, in a physical sense, composed of very little other than molecules fitted together, and the lecturer's every act of thought and speech involves rearrangement of his own constituent molecules. Such matters are very complex, but some help towards their understanding may come from the study of how simpler molecules pack in non-living material.

Molecules have shapes, some rigid, some flexible, determined by the distances between their linked atoms and the angles between the links. For packing purposes each atom in the atomic skeleton may be looked upon as surrounded by a negatively charged electron cloud, so that a molecule may be pictured as something like a balloon of possibly very irregular shape. Chemical reactions, growth, drug action, carcinogenic activity, and many other matters are bound up in various ways with molecular shape. In contrast to the liquid and gaseous stages, in which molecules behave in many ways as spheres, the crystalline pattern has the molecules in fixed positions which are determined by the manner in which their shapes can be packed. A general principle is that the molecules under the influence of their attractions tend to be closely packed, globules like piles of shot, cylinders like cigarettes or sloping like packs of books in a partly filled shelf; disks parallel like a pile of plates. More localized attractions between particular parts of neighbouring molecules, for example, strong spatially directed attractions through hydrogen in neighbouring water molecules, may act in a contrary sense, and by limiting the positions in which one may be placed relative to its neighbours, may lead to very open structures such as that of ice.

In some crystals molecules are bound, through hydrogen bonds or in other ways, to form larger aggregates. These sometimes may extend indefinitely in one or two dimensions, when the problem of packing them becomes that of arranging extended cylinders, ribbons, flat sheets, corrugated sheets, or related forms. If the aggregate extends indefinitely in three dimensions it constitutes the whole crystal and there is no further packing problem so far as that structure itself is concerned.

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Molecular structures of great geometrical complexity may be designed, and sometimes a close packing is impossible. Sometimes, molecules of two or more different kinds, if they are present in some suitable mixture, will together form a crystalline molecular compound. The manner in which molecules of different kinds thus fit together in regular or irregular arrays gives further information on the general principles of molecular packing.

Among the molecular packings in crystals, which were illustrated, were those in which similar or different shapes adjoin, and some where one shape encloses another. Others may interpenetrate like the links of a chain or become interlocked in a manner analogous to that used in a zip fastener. The dimensions and regularity of patterns formed by adjoining or enclosing molecules of two kinds can be related to the dimensions of the participating molecules.

J. MONTEATH ROBERTSON

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NEWS and VIEWS

Botany at the Imperial College of Science and Technology: Prof. W. O. James, F.R.S.

THE news of the appointment of Dr. W. O. James to the chair of botany and headship of the Department at the Imperial College of Science and Technology will be received with satisfaction by British botanists. He succeeds Prof. P. H. Gregory, who has been appointed head of the Department of Plant Pathology, Rothamsted Experimental Station (*Nature*, **181**, 158; 1958; **172**, 838; 1953). Dr. James began his botanical career as a student under Prof. Walter Stiles at what was then University College, Reading, and after obtaining a first-class honours degree in the University of London, for which Reading students then sat, he worked on problems of photosynthesis with the late Dr. F. F. Blackman at Cambridge. This was followed by a period at Rothamsted, where he examined the effect of potassium on carbohydrate metabolism. In 1928, Dr. James joined the staff of the Botany Department at Oxford, then under the direction of the late Prof. (afterwards Sir Arthur) Tansley. At Oxford, Dr. James has built up a very flourishing school of research in plant physiology, attention having been chiefly directed to the mechanism of plant respiration, for the elucidation of which, and the establishment of its essential identity with that in animal tissues, the work of James and his pupils has been largely responsible. This work has been described in numerous papers which have appeared mainly in the *Proceedings of the Royal Society*, the *New Phytologist* and the *Biochemical Journal*. During the Second World War, as part of the Oxford Medicinal Plants Scheme, Dr. James devoted much time to the study of alkaloid metabolism and its relation to respiration. As well as his well-known monograph on "Plant Respiration", published in 1953, Dr. James is the author (jointly with Prof. A. R. Clapham) of "The Biology of Flowers", published in 1935, in which the authors dealt with the forms of flowers of a representative selection of species and their relations to insect visitors. His "Introduction to Plant Physiology" is also well known. Since 1932 Dr. James has been one of the editors of the *New Phytologist*.

Museum of Natural History, Washington: Dr. A. C. Smith

DR. A. C. SMITH has been appointed director of the Museum of Natural History of the United States National Museum. He has been programme director for systematic biology with the National Science Foundation. Of special interest in this appointment is that, prior to his affiliation with the National Science Foundation, Dr. Smith was, for eight years, curator of the Division of Phanerogams in the Smithsonian Institution's Department of Botany. He now returns to the Institution to direct the Bureau, which includes the Departments of Anthropology, Zoology, Botany and Geology. In addition to directing the activities of the Museum of Natural History, Dr. Smith will continue his work in phanerogams, a research area of paramount importance. To date, Dr. Smith has published some 135 technical papers concerning this phase of botanical research. He received his Ph.D. in 1933 from Columbia University in New York City. Thereafter, he was associated with the New York Botanical Garden and the Arnold Arboretum of Harvard University. In addition to study and research in England, France, Switzerland, Germany, Holland and the Scandinavian countries, he has participated in several botanical expeditions to Colombia, Peru, Brazil, Fiji, British Guiana, and the Lesser Antilles.

Supreme Headquarters Allied Powers Europe: Dr. J. W. Abrams

DR. JOHN W. ABRAMS, of Ottawa, who is a member of the Canadian Defence Research Board and scientific adviser to the Chief of the Air Staff since 1954, has been loaned to Supreme Headquarters Allied Powers Europe (SHAPE) to undertake important duties in connexion with the scientific analysis and planning of Western European air defences. Succeeding him at R.C.A.F. Headquarters is Dr. J. C. Arnell, of Ottawa, the Board's director of plans. Both Dr. Abrams and Dr. Arnell assumed their new duties on September 1. General Lauris Norstad, supreme allied commander, Europe, requested Dr. Abrams's services because of his wide experience in the field of operational research and, in particular, with the various scientific problems relative to air defence systems. He played a prominent part in investigating the scientific aspects associated with the planning of Canada's air defence effort.

Research on High-energy Nuclear Particles

THE U.S. National Science Foundation has made a grant of 450,000 dollars to the University of Chicago for high-energy nuclear particle research with balloons. The team will be led by Dr. Marcel Stein, of the University. The balloon flights will be part of a project investigating cosmic rays in the region of 10,000 BeV. Large stacks of photographic sheet emulsion will be sent by unmanned 'Skyhook' balloons to an altitude of 120,000 ft. for a 24-hr. period. Pressurized, light-tight gondolas attached to the balloon will contain the stacks, each of which measures approximately 2 ft. × 1½ ft. × 1 ft. This is about five times the size of comparable film stacks which have previously been sent up. A particle from outer space, such as a proton, entering the stack collides with a heavy atomic nucleus in the emulsion and the resulting nuclear explosion generates a jet of very energetic particles. This jet, like a burst of particles in an accelerator, strikes other nuclear targets and produces a whole series of new nuclear reactions, all recorded on the emulsion stacks. The purpose of the study, which will continue for three years, is to investigate high-energy elementary nuclear particles which can only be observed at the high altitudes reached in balloon flights. Calculations show that the flights should yield a substantial number of collisions above 10,000 BeV. and as many as 30,000 interactions at the lower but still significant 100-BeV. energy level. Quantities to be measured by the experiment include: primary energies of nucleons, number of charged and neutral secondary particles, interaction mean free paths of secondary particles, cross-sections from primary and secondary interactions as a function of their energy, energy loss per collision of nucleons, angular and energy distribution of secondary particles as a function of primary energy, energy spectra of heavy nuclei, and break-up in the cosmic radiation.

New Round-the-World Telephone Cable

THE construction of a round-the-world Commonwealth telephone cable was considered at the Commonwealth Trade and Economic Conference in Montreal. It was envisaged that its provision would be based on capital contributions from all Commonwealth countries and that the new cable could be operated on a self-supporting financial basis. The first trans-oceanic telephone cable was opened in 1956 between the United Kingdom, Canada and the United States, and the construction of a further cable between Canada and the United Kingdom is expected to be completed in 1961. This would form the first part of the new Commonwealth link. The rest of the route considered by the experts would be as follows: the west coast of Canada would be linked with New Zealand and Australia, and from there the cable would run through the Indian Ocean connecting Malaya, India, Pakistan and Ceylon, and from these countries by way of Kenya to South Africa. By providing a link between South Africa and the United Kingdom, connexion would be made with trans-Atlantic telephone cables.

The order of construction must be a matter for further consideration by Commonwealth Governments, but it may be that the existing and proposed links from the United Kingdom to Canada would first be extended by a cable from the United Kingdom to South Africa and a cable across the Pacific to New Zealand and Australia; the links spanning the Indian Ocean, to be constructed later, would complete the girdle of the world. The conference estimated that the total length of a round-the-world telephone cable of this nature would be about 27,000 nautical miles, or nearly 30,000 nautical miles if the trans-Atlantic crossing is included. The construction cost was estimated at £88 million, including the trans-Atlantic cables.

Russian Scientific and Technological Literature

THANKS to the co-operation of many organizations in Britain and abroad, the Department of Scientific and Industrial Research Lending Library Unit now has a growing collection of recent Russian scientific and technological literature. Despite its imperfections, it is already the largest in Western Europe. Lists of what Russian literature has been received are being issued, but the demand for this literature is not very great. It is clear that owing to the linguistic difficulties something more than the traditional library methods of making known what is available is required. Suggestions for new services will be considered. Whenever translations of Russian into English become available the Unit obtains copies if the cost of the translations is less than the actual cost of making new translations. Nevertheless, these measures by themselves appear to be inadequate, so it has been decided to initiate a translating programme. The basic idea behind the programme is that financial assistance should be available where necessary to help specialist organizations to select, translate and arrange for the publication of the important Soviet scientific and technical literature in their fields. This programme is being drawn up to avoid any duplication with the translating activities in the United States, and details about it will be made known later. Further information can be obtained from the Unit at 20 Chester Terrace, London, N.W.1.

New 'Area of Outstanding Natural Beauty'

THE Minister of Housing and Local Government, Mr. Henry Brooke, has confirmed an Order made by the National Parks Commission under the National Parks and Access to the Countryside Act, 1949, which has the effect of establishing about 26 square miles of countryside in Staffordshire, including Cannock Chase, as an 'area of outstanding natural beauty'. The area extends between Brocton, Tixall, Rugeley and Gentleshaw and also includes Shoal Hill Common to the south-west of Cannock Chase. Government grants can be made at the rate of 75 per cent towards the cost of treating derelict land, tree planting and preservation, and removing disfigurements. Grants are also available towards expenditure incurred in making agreements or orders for public access to open country and in appointing wardens. Designation does not of itself provide any additional right of access to private land. This is the sixth such area to be established. The others are: the Quantock Hills and Surrey Hills in the south of England, the Northumberland coast in the north, and the Gower and Lleyn Peninsulas in Wales.

Corby Young Naturalists' Club

CORBY Young Naturalists' Club is now in its fourth year (*School Nature Study*, 53, No. 211; April 1958). It was formed first as a group of school children who liked rambles with someone who could identify and talk about the things they saw. From there it grew to a fully fledged club with meetings and a definite object to the rambles—a 'survey' of the local woods. Field work formed the basis of the Club. So many children were interested, and joined in the activities in their spare time, that it has been found necessary to work, not as a body, but in groups.

with older children acting as the leaders. After an excursion all gather together and the various records are taken and discussed. Any doubtful record is checked in the field. All records are then entered in a book to be held for future reference. During the school holidays other field work, such as counts of birds, counts of plants in a square, or series of squares, transects of areas, and similar studies are carried out. Certificates are awarded for individual field work, or individual study. 'Report forms' are also issued to all members to encourage them to record things they see. On these records the annual report is based. One evening a week during term-time a school classroom is hired and an indoor meeting arranged. This consists of a film or film-strip, or talk by experts on a variety of subjects ; the subjects are chosen by a committee of children. Outings to places of interest are also arranged. These include marshes, woodland areas, a heronry, a large winter roost for rooks and a winter roost for gulls. There is a small club library, from which the children may borrow books.

Courses on Nuclear Energy in Europe

A NEW edition of the "Catalogue of Courses on Nuclear Energy in O.E.E.C. Countries", covering the academic session 1958–59, has recently been issued by the European Nuclear Energy Agency of the O.E.E.C. (pp. 115. Paris : European Nuclear Energy Agency, Organization for European Economic Co-operation, 1958. 2, rue André-Pascal, Paris 16). It lists details of the courses on nuclear physics, nuclear engineering and related topics to be held in universities, technical colleges and research centres, together with practical information such as the names of the instructors or professors in charge, the durations of the courses, conditions of admission, fees, and the special pieces of equipment available. The information provided is not regarded as complete, but the catalogue should enable science and engineering students who wish to acquire a better knowledge of nuclear subjects to find out what training facilities exist and where and how to apply for them. The intending student is warned in the foreword that further information concerning any particular course should be obtained directly from the institution concerned, but it would have been perhaps wise to repeat this warning boldly throughout the catalogue, because in the case of the United Kingdom institutions, for example, the information given is neither well nor systematically chosen. To university authorities and others the catalogue will also be useful as a means of comparing the programmes of instruction in the educational establishments of the numerous countries listed and as a means of assessing the extent to which nuclear energy work has developed.

National Institute of Industrial Psychology Courses

THE National Institute of Industrial Psychology has issued details of courses and seminars arranged under its auspices during October 1958–May 1959. These include courses on personnel selection methods, held in three parts each of one week's duration, with two fourth parts, each of three days duration (open to those who have already attended the first three), on the selection of clerical personnel or, alternatively, of engineering apprentices. A course on the use of statistics in personnel management has been arranged jointly with the Institute of Personnel Management. A three-day course on staff reporting and merit-rating procedures, a five-day course in vocational guidance for youth employment officers and careers teachers, and two three-day seminars on psychological problems in inspection work and on personnel work in research organizations have also been arranged. Further particulars can be obtained from the Courses Secretary, National Institute of Industrial Psychology, 14 Welbeck Street, London, W.1.

Computer Symposia

THE 1958 Computer Applications Symposium, organized by the Armour Research Foundation of the Illinois Institute of Technology, is to be held in Chicago on October 29 and 30. The purpose of the symposium will be to discuss computing and data processing devices from the point of view of users of such equipment. Business and management applications of computers will be stressed on the first day, engineering and scientific applications on the second day. Forms of application and further information can be obtained from M. J. Jans, Conference Secretary, Armour Research Foundation, 10 West 35th Street, Chicago 16, Illinois.

A Business Computer Symposium is to be held at Olympia, London, during December 1–3, in conjunction with the Electronic Computer Exhibition being held during November 28–December 4. An opening address is to be given by the Earl of Halsbury, managing director of the National Research Development Corporation, at whose instigation the Exhibition and Symposium have been organized jointly by the Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association. The papers to be presented will cover practical experience of the use of computers for pay-rolls, production planning and management, file maintenance, public utility accounting, farm accounting, banking, insurance, stores control, research and design. Enrolment forms and further information can be obtained from the Electronic Computer Exhibition, 11/13 Dowgate Hill, London, E.C.4.

Announcements

SIR ALEXANDER FLECK has been appointed chairman of the Scientific Advisory Council of the Ministry of Power, which was set up in 1948 to advise the Minister on the scientific aspects of his statutory duties. Its first chairman was Sir Alfred Egerton, followed in 1954 by Sir George Thomson.

THE Institute of Personnel Management is holding its 1958 National Conference during October 10–12 at Harrogate, on the theme "The Individual and the Organization in Modern Society". Further information can be obtained from Miss E. M. Harris, Institute of Personnel Management, 80 Fetter Lane, London, E.C.4.

A SYMPOSIUM on "The Tools of Biological Research" is to be held in the Physiology Theatre, Guy's Hospital, London, S.E.1, on October 10 and 11, when the opening address will be delivered by Sir Cyril Hinshelwood. Further information can be obtained from Mr. H. J. B. Atkins, Department of Surgery, Guy's Hospital.

ERRATUM. In the article "Partition of Proteins in Liquid Polymer–Polymer Two-Phase Systems", by Dr. Per-Åke Albertsson, in *Nature* of September 13, p. 709, 'System *G*' should read 'System *C*' in : (1) Table 1, column 3 ; (2) the legend to Fig. 2 ; (3) p. 710, column 2, eighth line from the bottom.

MODERN EDUCATIONAL TREATMENT OF DEAFNESS

UNTIL recently there has been less investigation of hearing and of auditory perception than of vision and visual perception. Modern technological advances have made it possible for workers in a number of fields to gain much new knowledge about hearing. The International Congress on the Modern Educational Treatment of Deafness, which was held in the University of Manchester during July 15–23, was attended by more than 1,000 members from forty-one countries and was the largest of its kind ever to be held. It was distinguished also for its comprehensive and eclectic character. Papers on recent advances in the physiology of hearing, the pathology and causation of deafness in childhood, experimental phonetics, psycho-acoustics and audiology and the educational treatment of deafness attracted a 90 per cent attendance throughout the duration of the Congress. Audiences that included leading medical consultants and authorities on electro-acoustics and many outstanding educators of the deaf from almost all parts of the world followed papers and demonstrations of work in each others' fields with the closest attention.

The view was frequently expressed and evidently widely accepted that new scientific data about hearing are increasingly important and indeed basic to the treatment of deafness in childhood, and that the teamwork of experts in all relevant fields which is already in operation in certain centres constitutes a necessary practical approach.

Dr. Hallowell Davis, so long well-known for outstanding experimental studies in audiology at Harvard University and the Central Institute for the Deaf, St. Louis, reported that the electron microscope has now revealed many details of structure of the sense organ of the ear. The 'hairs' on the sensory hair cells of the cochlea now stand out clearly. There are considerable and probably important structural differences between the internal and external hair cells. An alternating-current output—the familiar cochlea microphonic—comes from the external hair cells, while a direct current comes from the internal hair cells. The internal hair cells seem to resist the action of poisonous drugs and the mechanical stresses of high-intensity sound more successfully than the external hair cells, which appear to be more sensitive, more specialized and relatively recent in origin. The external hair cells make possible the detection of extremely faint sounds. Small differences in the times of arrival of individual sound waves at our two ears are detected by the external hair cells and the fibres connected to them and are one basis for our localization of the source of sound in the external world.

Microchemical studies of the fluids of the inner ear show that the endolymph within the membranous labyrinth is a tissue fluid of unique chemical composition. It has a high concentration of sodium. It has not yet proved possible to relate the possible physiological and neurological abnormalities that may be represented by recruitment and by Ménière's disease to the new physiological findings of chemistry and electro-physiology. An unexpected finding has been the demonstration of a bundle of nerve fibres that runs from the brain stem to the sense organs. Galambos has demonstrated that appropriate stimulation of this pathway (in cats under laboratory conditions) reduces the sensitivity of the ear.

Prof. Ormerod (Institute of Laryngology and Otology, University of London), in a paper on the pathology of congenital deafness, defined deafness in the very young child as due to failure to develop of some part of the auditory mechanism, or to a degeneration or a disturbance of some part, already developed, of this system. The factor interfering with the development of the ear must be operative during the first half of the period of gestation. There may be complete failure to develop of either acoustic or static parts of the internal ear. The basal coil of the cochlea may take shape but not the middle and apical turns. In the commoner form of congenital change the bony labyrinth is perfectly formed, the membranous and sensory vestibular organ is fully developed and functioning, but in the cochlea the scala media is usually collapsed and the organ of Corti is represented by a small heap of undifferentiated cells. Not all the children who suffer from congenital deafness are totally deaf, but as shown by Whetnall, the great majority have some islands of hearing and may be described as sub-totally deaf. (A similar finding has been reported from Manchester.)

Mr. Harrison, in a paper on the etiology of deafness in childhood, and Dr. Watson, dealing with factors affecting the successful use of hearing aids by deaf children, reported some results of a collaborative project for which a joint team of senior members of the staffs of the Manchester Department of Education of the Deaf and of Otolaryngology have been responsible, for a number of years, with the support of the Medical Research Council. In certain cases of deafness in childhood, for example, of malformation of the external and middle ear, capacity to hear had been improved after operative treatment, by contrast with cases of deafness associated with a history of kernicterus, which are not amenable to treatment. Familial perceptive deafness was characterized by a flattish type of audiogram, with hearing losses of about 80 decibels and by pure-tone determinations indicative of severe high-tone loss.

Dr. Goodhill (Los Angeles), in a paper given by means of a sound-recording, described recent surgical advances involving many procedures for reconstituting the middle ear, in children as well as in adults, with the view of enabling transmission of sound energy to the cochlea.

Results of systematic research on the capacity of children to benefit from the use of hearing aids were reported in several papers. Prolonged studies of groups of children in different categories of auditory impairment were stated by Dr. Watson and by Dr. Hudgins (Clarke School for the Deaf, Massachusetts) to have shown that no deduction about capacity to hear speech can be made from the pure-tone audiogram alone. In the joint investigation at the University of Manchester it had been demonstrated that some cases of perceptive deafness and most cases of conductive deafness could discriminate speech.

As regards profoundly deaf children, a study of fifty pupils of the Clarke School who were profoundly deaf, over a five-year period had shown that their speech perception scores, when tested in the condition of listening with a hearing aid, and looking, were significantly higher than in the condition of lip-reading alone, and that the scores consistently improved in both conditions.

Prof. Bordley and Prof. Hardy (Baltimore) reported that since the Hearing and Speech Center of the Johns Hopkins Medical Institutions was established in 1947, intensive medical and neurological studies of children had led to a concept of hearing problems as no longer centred principally in the ear and naso-pharynx, nor in the family background. Approximately 70 per cent of the pre-school age children referred to the Hearing and Speech Center gave evidence of central disorders of trauma or mal-development at the level of the brain, with or without peripheral involvement.

A valuable paper on hearing aids was given by Dr. Littler (Medical Research Council, London), who described the peculiar problems that arise when attempts are made to equalize frequency response of the whole aid, with its three elements of microphone, amplifier and reproducer, by the combination of selective response in two different bands of sensitivity of microphone and reproducer.

Mr. Fant (Stockholm), discussing the acoustics of speech, described intensive studies of vowel articulation which have resulted in a three-parameter specification of the vocal tract configuration. He demonstrated speech that was artificially produced. This paper was appropriately followed, at a later session, by one in which Mr. John (Department of Education of the Deaf, Manchester) reported experiments that have shown the detrimental effects of reverberation and noise in rooms on the intelligibility with which speech can be heard through hearing aids and the great deterioration in scores that accompanies increase in distance of speaker from microphone. The acoustics of rooms, in which the amount of reverberation that is present is completely tolerable to listeners with unimpaired binaural hearing, can offer the greatest difficulty to users of hearing aids. Reference was made to spectrographic studies that demonstrate the distortions of vowel and consonant formants that take place. Mr. Thomas, who has collaborated with Mr. John, read a paper on the application of their findings in architectural acoustics to the design and construction of schools for the deaf and the acoustical treatment of new schools, as now practised on their advice in many parts of the United Kingdom.

Closed-circuit television broadcasts were given during two sessions. The first was introduced by Dr. Irene Ewing, who described how the diagnostic practices of the Manchester department had grown out of her own direct and original study of the highly selective reactions to sounds made by normal very young children. Under her direction, screening tests of hearing suitable for children from four months to five years were given by health visitors from the public health departments of the City of Manchester and Caernarvonshire (in Welsh), to whom with some thousand others in many parts of the United Kingdom, she had given special training. Parent guidance and the results of home training, including the use of hearing aids, with children aged from eight months to five years, were shown by Dr. Ian Taylor and Mrs. Beaman. In a paper on this subject, Prof. Huizing (Groningen) gave results of experiments that demonstrated how a home-trained child, wearing a hearing aid from the age of sixteen months, achieved a more rapid growth of expressive language than children who had audiological treatment and conventional oral training from their fourth birthdays onwards. Prof. Huizing stressed the importance of auditory feed-back in the linguistic development of deaf children, that is, of enabling them to hear their own voices, and so far as possible their own speech.

In a short article it is possible only to mention a few of the many excellent contributions made by teachers of the deaf serving on the staffs of schools, and educational psychologists. Among the most notable was a demonstration, introduced by Father van Uden, of some methods and results of training profoundly deaf children to respond to the sound of speech and music, when very loudly reproduced. Some pupils of the Institute for the Deaf, Sint Michielsgestel, aged 11–12 years, all of whom were profoundly or sub-totally deaf, were given a lesson in the course of which they were seen composing 'play-songs' or simple melodies to which they afterwards danced. Then a similarly constituted group of girls aged 13–18 years showed their notable capacity to dance ballet to music reproduced from a battery of specially designed loud-speakers, at an average peak sound-level of 95 decibels above 0·0002 dynes per sq. centimetre. The late Dr. Becking with Father van Uden made experiments that led them to conclude that profoundly deaf children can learn to perceive feelings of vibration in the body, in response to abnormally loud sound and that these feelings are an introduction to, and an enrichment of, sound-perception in the ears, the basic principle being a feed-back between sound-perception and bodily movements.

Equally significant, in a different way, was a demonstration by closed-circuit television in which severely, profoundly and sub-totally deaf pupils from the Nursery-Infant Branch of the Royal Schools for the Deaf, Manchester, aged 7–8 years, under Miss Goldsack, showed remarkable spontaneity and capacity to express themselves verbally, with a standard of general knowledge that would have done credit to a better than average class of unhandicapped pupils. They were taught in a classroom wired for induction, which enables them to move about freely without losing the teacher's voice. Five of them had had home training. Demonstrations were given by older boys and girls, using similar equipment, from the Royal Cross Schools, Preston, and the Braidwood Schools, Birmingham. Dr. Schmaehl (Dortmund) and Mr. Mikaelian (Moscow) reported extensive use of inductance systems in their countries.

Attention was frequently directed to problems in the social development of deaf children. Miss Numbers (Clarke School, Massachusetts) and Mr. Askew, principal of the English Grammar School for the Deaf, gave details of the wide ranges of occupations that are being followed by well-educated ex-pupils of good ability. Dr. Buchli, director, Royal Institute for the Deaf, Groningen, stated that he had found that children who could not be day-pupils developed more normally when living with foster-parents than in a residential special school. Dr. Murphy (Melbourne) and Dr. Silverman, director, Central Institute for the Deaf, St. Louis, referred to deaf men and women who seek social life among others who are similarly handicapped. Dr. O'Connor, superintendent, Lexington School for the Deaf, reported use of tests and procedures for evaluating the capacity of boys and girls handicapped by deafness to benefit from attendance at ordinary schools. Mrs. Miller (Clarke School) described some methods of social training for senior pupils. An important paper by Prof. Lewis (University of Nottingham) on language perception and reasoning was supported by one from Dr. Morosova (Moscow), in which she described capacity to use words in thinking as a leading determinant of cognitive activity. Several speakers, including the writer of this article, discussed the achievement of this capacity as a factor in the social development of deaf children, and the deviation of their mental growth from normal when it is begun later than among children who are not deaf.

A. W. G. Ewing

NATURE AND GENETICAL CONTROL OF RESISTANCE IN LIVING ORGANISMS

THE nature and genetical control of resistance in living organisms was considered at a joint session on September 1 of Sections *D* and *K* (Zoology and Botany) of the British Association at the Glasgow meeting. The topics were disease resistance in plants and animals, insecticide resistance in mosquitoes and drug resistance in bacteria.

In the opening paper Dr. P. R. Day (John Innes Horticultural Institution) outlined the types of genetical control of resistance to pathogens in higher plants. These range from the single, usually dominant, gene through complementary action of two or more genes to polygenic control. There is a similar pattern in the genetic control of virulence in fungal pathogens selected by cultivation of resistant crop varieties. At the single-gene level this has led to the suggestion of a gene-for-gene relationship whereby the outcome of host infection by a pathogen depends on the alleles present at complementary loci in both organisms. A resistance gene in the host is only effective if there is a corresponding avirulence gene in the pathogen. An example of how the gene-for-gene concept may be applied comes from work at the University of Wisconsin on the inheritance of avirulence among a group of strains of *Venturia inaequalis* (apple scab) on seven apple varieties. The genes for avirulence were identified and separated in recombinant stocks. From the results of inoculations it was possible to estimate how many genes for resistance were present in each apple variety and which genes for resistance were common to two or more varieties. The interaction of gene products of the host and pathogen enables the host to recognize that the pathogen is avirulent. This recognition triggers secondary reactions which kill or limit the pathogen growth. Mutants of *Cladosporium fulvum* (tomato leaf mould) and *Melampsora lini* (flax rust) can be obtained which presumably avoid the recognition reaction and are thus virulent on a particular host resistant to the original strains.

Miss C. E. Jackson (Ross Institute of Tropical Hygiene) described the appearance of resistance to chlorinated hydrocarbon insecticides (dieldrin, BHC and DDT) following their use to control natural populations of malaria-carrying anopheline mosquitoes. Laboratory studies showed that resistance to dieldrin in a strain of *Anopheles gambiae* from Northern Nigeria was some 800 times higher than that of wild-type insects of that species and was controlled by a partially dominant single gene. A discriminating dose of the insecticide enables hybrids to be distinguished from the homozygous resistant parent. DDT resistance in *A. sundaicus* from Java was controlled by a single recessive gene. In laboratory experiments it was possible to raise the level of tolerance of mosquitoes to insecticides by exposures to sublethal doses during twenty generations of larval selection. The level of tolerance achieved was never more than seven times that of the original stock and this fell when larval treatments were stopped. This 'vigour tolerance' may be associated with inversions found in the chromosomes of treated stocks. The importance of this problem is shown by the fact that resistance to the insecticides dieldrin, BHC and DDT and its analogues is now found in eleven countries in six species of mosquito. No example of simultaneous resistance to DDT and dieldrin or DDT and BHC has yet been proved.

Dr. Mary Barber (Postgraduate Medical School, London) described three types of drug resistance found in bacteria: drug tolerance, drug dependence and drug destruction. The first two types of resistance generally arise by mutation. Drug destruction is often due to formation of an adaptive enzyme such as penicillinase in some penicillin-resistant bacteria. The initiation of enzyme production by strains previously producing none probably results from mutation. The genetic transfer of drug resistance between cells can be accomplished in the laboratory by deoxyribonucleic acid extracts (transformation), by a virus vector (transduction) and by direct transfer of a bacterial chromosome, or parts of it, when cells are in contact (conjugation). The extent of these processes in Nature is unknown, although favourable conditions exist in the human flora or in the soil. The accumulation of drug-resistant strains of *Mycobacterium tuberculosis* and *Staphylococcus aureus* in hospitals has become a major problem. A study of penicillin-resistant *S. aureus* carried in the noses of pupil midwives in a London hospital showed a rise from 24 per cent carrying such strains during their first two weeks in the hospital to 60 per cent after three months. Of the permanent hospital staff 90 per cent carried resistant *S. aureus*.

The most successful approach to the control of both bacteria and mosquitoes is likely to be the simultaneous use of two or more drugs or insecticides. This makes it less likely that resistant mutants will develop. Plant breeders also try to release new disease-resistant crop varieties having two or more different resistance genes for the same reason.

Dr. A. Kleczkowski (Rothamsted Experimental Station) surveyed resistance to virus diseases in animals and plants. Resistance in plants is in a special category because of the absence of any immunity reaction comparable to the antibodies of the γ-globulin fraction of animal serum proteins.

Plant resistance may be due to failure of symptom expression, to interference, whereby infection with a mild strain protects against infection with a more virulent related virus, or by resistance mechanisms which result in localized death of host tissue preventing virus multiplication. Virus resistance may also be due to the host being inappropriate. Although antibodies may control the spread of virus from cell to cell, virus inside animal cells is not accessible to antibody and its amount is controlled by the rates of virus reproduction and inactivation. At higher temperatures the rate of inactivation tends to predominate and this has been used to cure virus diseases.

Virulent mutants of fungal and virus pathogens, drug-resistant bacteria and insecticide-resistant mosquitoes all arise as a result of high selection pressures. These pressures can be demonstrated even in entirely natural populations, resulting, for example, in the multiplicity of strains of *Phytophthora infestans* to be found on wild populations of *Solanum demissum* in Central Mexico.

Undoubtedly more is known about the genetical control of resistance than about its nature at the present time. As more is found out about both, so we shall be better able to use and control resistance.

P. R. DAY

SCIENCE IN SCHOOLS

THE Glasgow meeting of the British Association emphasized the need to reveal and encourage scientific aptitudes from an early age, and, with this in view, a special programme for young people was devised.

The Scottish Branch of the Science Masters' Association arranged an exhibition, open every afternoon, in which typical class apparatus and experiments were demonstrated and explained by boys and girls from Glasgow schools. Both children and teachers took great interest in discovering how other schools carried out familiar experiments and confirmed well-known principles. At the same time the presence of one or two less-common pieces of apparatus, such as the van de Graaff generator, provided a little extra interest and removed the school-room atmosphere. Unilever, Ltd., had a display of charts, booklets and film-strips which are available for schools, and some of the material advantages of modern science were shown in interesting exhibitions of samples, charts and models provided by Imperial Chemical Industries, Ltd., and the United Kingdom Atomic Energy Authority.

Each afternoon of the meeting three special children's lectures were delivered concurrently, and on August 28 the boys and girls had the difficult choice of hearing Sir Lawrence Bragg on "How we hear and speak", Dr. H. Barnes on "Under-water Television" or Mr. A. E. Gunther on "Geology and Oil". Those with tickets for August 29, September 1 and 2 were in no less difficulty, since they had to choose from the following list: "Atomic Energy" by Dr. T. E. Allibone, "Prehistoric Animals" by Dr. W. E. Swinton, "Thunderstorms, Hail and Lightning" by Dr. B. J. Mason, "Exploring Flowers" by Dr. G. Taylor, "Man-made Fibres" by Mr. A. B. Thompson, "The Electronic Brain" by Dr. A. D. Booth, "Animal Clocks and Compasses" by Dr. J. D. Carthy, and "Man in Flight" by Wing-Commander P. D. G. Whittingham.

One of the features of the meeting was an open forum held on Saturday morning. Sir Alexander Fleck introduced the chairman, Dame Kathleen Lonsdale, and her panel of experts consisted of Dr. I. J. Faulkner, Mr. B. B. Lloyd, Dr. B. J. Mason and Dr. W. E. Swinton. The questions, sent in by schools in the west of Scotland, showed pronounced topicality with considerable emphasis on space travel and satellites, but the panel also had to deal with some searching questions on the nature of colour, world population and the possibility of extinction of the human species. Some uncertainty was evident among the panel when asked to define matter, but Dr. Swinton was in no doubt that the homing instinct in the pigeon was in no way due to any extra sense organ in the bird.

On Tuesday morning, at the invitation of Section *X*, some sixth-form boys read original papers. Mr. A. M. J. Hutchings and Mr. A. J. Nicholl, of the High School of Glasgow, dealt very authoritatively with "Plant Ecology of Heather, Moor and Bog", while Mr. Alan Nicol gave a concise account of "The Production of Special Steels", as did Mr. J. C. Natzio with "The Work of *Discovery II*". Both these speakers are scholars of Hutcheson's Boys' Grammar School, Glasgow. Mr. D. W. McCredie of Charterhouse read an excellent paper on "The Breeding Habits of the Hen Harrier in South-West Perthshire".

At a conference of affiliated societies, Mr. R. A. Stevens outlined the future policy of the British Association with regard to the Junior B.A. The plan requires the setting up of area committees (several are already in being and eight or nine are expected by the end of the year), which would work in co-operation with local societies to provide lectures, meeting places and organized excursions. In addition to supplying the needs of adult audiences, these area committees will do all they can to encourage school scientific societies to expand and to serve as a centre of scientific culture in the schools from which interest in science would emanate downwards into the junior classes and across into the arts side of the school. In order to give the fullest assistance to scientific societies in schools, the British Association is setting up a committee for the purpose of devising suitable visual aids, and local societies are being encouraged to organize federations of school societies in their areas for the pooling of resources and exchange of ideas. Such a plan, it is felt, would be of great value to the adult societies since it would lead the children towards them and ultimately provide a source of recruits.

It is recognized by the British Association that the present plan of holding the Junior B.A. meeting at the same time as that of the parent body is possible only in the circumstances existing in Glasgow, where the city schools have just started the new term. To hold such meetings either in the school holidays or in mid-term would be quite impracticable, and it is proposed that in future the junior meeting shall be held at the end (or beginning) of the school year in whatever area is acting as host that year.

ERIC WALKER

UNEMPLOYMENT AMONG WOMEN OVER FORTY

UNLIKE many societies where the bulk of the economic load is carried by women, Western culture in general and British society in particular have inherited a tradition that opposes the gainful employment of women. To the employer women workers present problems different from those of men. Employers declare that if a woman is single she tends to be temporary, filling in time until she is married; and that if she is married she has domestic responsibilities which may make her unreliable as a worker. The sickness-rate is said to be higher among women, though here it is difficult to get reliable statistics. A woman is also said to age sooner than a man, though her average expectation of life is greater. The precise accuracy of these statements is not known; the fact that they are widely believed creates an employment complication of considerable significance.

Four surveys of unemployment among women over forty years of age in the Southampton area have been made by Miss A. F. Young of the University of Southampton (*Personnel Management*, 40, No. 344; June 1958). The total number of women employed in the area has risen from about 19,000 in 1951 to more than 23,000 in 1956, and total unemployment has fluctuated between 363 in 1954, and 472 in 1953, or about 2 per cent of all women in work or seeking it. Of the women unemployed, the number over forty has varied between 88 in 1951 and 204 in 1953, that is, between about a quarter and a half of the total, though in the last two surveys the proportion has been about a third. The figures show that the number of unemployed older workers remains obstinately high even when, as in 1954, unemployment was at its lowest. This leads to the assumption that a hard core of unemployment exists among those over forty.

Nearly half the number were found to be married women, with presumably a husband and a home. Of the rest the proportion of single and widowed fluctuated, but averaged a little more than 25 per cent each of the total. It was found, however, that unemployed single women over forty sometimes reached as much as 30 per cent of the whole (1954). When those over forty were analysed according to their age, it was found that more than half were fifty or older (57 per cent, in 1956); and getting a job becomes more difficult the older a woman grows.

The 'social' reason for discouraging the older woman to take gainful employment is her responsibility to dependent children; this is the reason why married women so often interrupt their employment for a number of years. The surveys disclosed that, of the 68 married and 43 widows over forty, only 19 had any dependent children and, of these, 7 were over fifty, the rest being under fifty. This was the position in 1956, and the figures for 1954 show a similar situation. It became clear that the demands of young children are not, on the whole, a complication to be contended with in the employment of women over forty.

It is often alleged that the majority of older women are not available for full-time work, either because their health is not good enough or their domestic responsibilities make it impossible or, having left industry for a number of years, they cannot face the discipline and strain of full-time work. The facts do not support this contention; nearly two-thirds of the women in two of the surveys have asked for full-time employment. Full-time work is more possible for those under fifty than later. Against this survey it was found that, of the small number of women over sixty looking for work, nearly all wanted it full-time.

Allied to the older woman's availability for work is her reason for seeking it. Three main reasons were given: that the wage would be her sole income; that she wished to supplement her own resources; or that she needed to supplement the family income. A fourth category of "other reasons" included the need for companionship, inability to break the habit of going out to work, and other non-financial causes.

From the evidence of these surveys there is some substance in the saying "too old at forty" where women are seeking gainful employment. If this notion is to be broken at all, and the reservoir of available labour exploited to the full for the increasing productivity of our society, then some positive steps seem to be necessary. Apart from extending the number of employers who adapt their works to meet the needs of women, like part-time work of various kinds, they might include propaganda about the advantage of maturity, training, and direct recruitment into domestic and catering trades where there are many vacancies and where many older women could usefully be absorbed.

SOUTHERN STARS OF HIGH VELOCITY

AS might be expected from the fact that observatories of the southern hemisphere are of comparatively recent origin and have fewer astronomers and telescopes at their disposal than those in the northern hemisphere, the data for large groups of southern stars are by no means complete. This lack of data is particularly noticeable in the determination of radial velocities, a survey of which was completed for stars brighter than magnitude 5·5. After the publication of Miss Roman's "Catalogue of High-Velocity Stars", which included stars north of Dec. −20° and brighter than visual magnitude 9·5, it was considered that a complementary list of southern high-velocity stars would be of great interest, but, owing to the lack of observational data, it will probably be many years before a survey similar to Miss Roman's will be completed. With the object of serving as a basis for future observations the present finding list, including all available information, has been published*.

As the criteria for inclusion in the list are less stringent than for Miss Roman's "Catalogue", it includes 1,315 entries—approximately twice the number in the more selective northern list. Tangential velocities were computed for all stars south of the celestial equator for which reliable trigonometrical parallaxes, that is, not less than 0·01″, were available, and tangential and radial velocities were corrected for a solar motion component of 20 km./sec. towards R.A. 18h., Dec. +30° relative to the nearby stars; a few other necessary corrections are also referred to. Included in the list are the stars the space velocities of which, relative to the local standard of rest, exceed 60 km./sec. as well as stars of which only one velocity component, which exceeds 50 km./sec., is known. In addition, stars the uncorrected proper motion of which exceeds 0·5″ annually and for which no further information is yet available are included. Globular clusters, planetary nebulæ and *RR* Lyr. variables, which obviously belong to population II, have been omitted, and reference is made to a number of other limitations.

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* Memoirs of the Mount Stromlo Observatory. No. 14 (Fourth Number of Vol. 3): Southern Stars of High Velocity—a finding list compiled by William Buscombe and Pamela M. Morris. Pp. 36. (Canberra: Australian National University, 1958.)

Of the 1,315 stars listed proper motions were available for 97 per cent, Draper spectral types for 59 per cent, reliable trigonometrical parallaxes, that is, not less than 0·01″, for 49 per cent, radial velocities for 33 per cent, and complete information for the space velocities only 18 per cent. An unexpected feature was the presence of 37 *B* stars, which are usually considered to form part of the Population I disk system in our Galaxy. It is pointed out, however, that in many cases there are large differences between the radial velocities measured from spectroscopic plates of the same star on different dates, which may indicate that some at least of these stars are undetected binaries with large ranges in velocity relative to the Sun: in nearly every case the parallax and tangential velocity component are unknown.

It is pointed out that new data concerning stars of high velocity will be available, as southern observatories have now many observational programmes under way, and reference is made to the work in progress at a number of these observatories, including the Cape, La Plata, Cordoba, Sydney, and the Yale-Columbia Southern Station, now located on Mount Stromlo, Canberra. A few new radial velocities for bright stars have been determined from Cassegrain spectra (36 A./mm.) at $H\gamma$ taken with the Mount Stromlo 30-in. reflector. Classification on the *MK* system for these and for faint stars with Newtonian spectra (90 A./mm.) from the 74-in. reflector is in progress. Forty suspected subdwarfs are included in the current observing list.

ADULT EDUCATION IN WALES

THE report of the Universities Council for Adult Education for 1956–57* is chiefly devoted to a survey of adult education in Wales.

For the purposes of extra-mural work the Principality consists of four college areas (Aberystwyth, Bangor, Cardiff and Swansea), and there are a North Wales District and a South Wales District of the Workers' Educational Association. All provision and administration of extra-mural work is carried out by the four university colleges, the areas of which differ from one another in a variety of ways. The Aberystwyth area is entire rural. The Bangor area is also rural for the most part, but it comprises in addition the industrial districts of Flintshire and Wrexham. The Cardiff and Swansea areas are predominantly urban and industrial.

The two-and-a-half million people of Wales are shared unequally between the four areas. Half of them are in the Cardiff area, while Aberystwyth serves a population of about 300,000 scattered over an area which covers almost half of the Principality.

The development of extra-mural work has also varied from area to area. After some tentative beginnings before the First World War, Aberystwyth appointed a director of extra-mural studies in 1920 and, with a small nucleus of full-time tutors, an extra-mural department came into existence. Workers' Educational Association work in the area has not been inconsiderable, but, unaffected by industry, the country folk of this area have not responded so readily to the appeal of an association of workers as have the inhabitants of the other college areas.

The course of events in the other three colleges has been quite different. A South Wales District of the Workers' Educational Association was formed in 1907. This was reconstituted as a Welsh District in 1910 and served the Principality as a whole until the establishment of a North Wales District in 1925. University teachers took a leading part as pioneers for the Association, and throughout the inter-war period the actual organization of extra-mural work in South Wales was conducted largely through the Workers' Educational Association District. Departments of extra-mural studies can scarcely be said to have existed at Cardiff and Swansea until, at the end of the Second World War, the senior staff tutor was appointed secretary of the Swansea joint committee and a tutor in charge of extra-mural classes was appointed at Cardiff. There are still no directors at these two Colleges, though such appointments are contemplated in the present quinquennium.

At Bangor the alliance between College and the Workers' Educational Association was closer still, and the extra-mural work was administered to a considerable extent through the Association's district officer.

Each responsible body has had its own particular story of successes and difficulties. The voluntary bodies in South Wales expanded their work in a spectacular way during the industrial depression of the nineteen-thirties, when a considerable amount of money from the Carnegie Trust was made available to them. In the post-war period, on the other hand, the programmes of these voluntary organizations have dwindled to little more than half their former size, while those of the extra-mural departments of Cardiff and Swansea have grown apace. A great deal of pioneer work was done by the Aberystwyth department during the war years, and although the high figures reached then have not been fully maintained in more recent years, the present volume of work is at least twice what it was before the War. In the Bangor area there has been a striking expansion of Workers' Educational Association classes since the War and an appreciable increase in the classes conducted by the extra-mural department.

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* Universities Council for Adult Education. Report on the Year 1956–1957. Pp. 27. (Bristol: W. E. Salt, Hon. Secretary and Treasurer, c/o Department of Adult Education, The University, 1958.)

Aberystwyth was the first to break away from the customary restriction of extra-mural work to tutorial and sessional classes, but, since the War, Cardiff has also been conducting an appreciable number of terminal and short courses, while Swansea has recently embarked upon a considerable programme of short extension courses. Apart from the addition of a few short extension courses, Bangor still limits itself to tutorial and sessional courses.

The Adult Education College established at Harlech in 1927 had thirty-nine students in residence for the session 1956–57, and fourteen others attended for a term or two. Almost all the sessional students were drawn from within the Principality, and about half of them were manual workers. But Coleg Harlech has always endeavoured to bring its Welsh students into contact with those of other nations, and this year most of its terminal students and one or two of its sessional students came from such countries as Austria, Hungary, Germany, Denmark, Jamaica and the United States.

Whereas the intensity in industrial South Wales is only slightly more than the average for England, class units in the predominantly rural areas of Aberystwyth and Bangor are three times as numerous as they are in England in relation to population. This is as true of tutorial and sessional classes as it is of other kinds of work.

The subjects of study do not differ fundamentally from those conducted by the other extra-mural departments of the United Kingdom, except that Welsh history predominates over other kinds of history, and Welsh literature over other literatures. Although conditions have changed in recent years, the persistence of old interests is revealed by such facts as that the physical and biological sciences are completely overwhelmed by the humanities, that courses on religious subjects figure about twice as prominently as they do in England, and that there are relatively few courses in the visual arts.

One of the major problems is that of finding sufficient part-time tutors who are really qualified for university work, and this is particularly acute in the rural areas. Each College has five full-time tutors, and these, together with members of the intra-mural staffs, take a third of the classes. In the Aberystwyth and Bangor areas it is often difficult to take full advantage of the teaching staffs of the colleges because most classes within a radius of forty miles from the college centre are conducted in Welsh, a language which three-quarters of the intra-mural staffs do not understand. Each college is obliged to depend upon part-time tutors—lecturers in training colleges and theological colleges, school teachers and ministers of religion—for the bulk of the teaching. The need for a substantial expansion in full-time staffs remains.

INFLUENCE OF CERTAIN INORGANIC IONS ON THE HATCHING OF THE POTATO ROOT EELWORM, *HETERODERA ROSTOCHIENSIS* WOLLENWEBER

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PREVIOUS studies on the influence of salts on the hatching and emergence of larvæ of plant parasitic nematodes have approached the problem largely from the point of view of their possible osmotic effect[1,2]. However, the demonstration that the hatching-factor of the potato root eelworm possesses cardiotonic properties[3] suggested that the nature of the ions might be of importance. As already briefly announced[4], this we have found to be the case.

After a preliminary soaking in distilled water, cysts have been stimulated with solutions containing chlorides of sodium, potassium, calcium and magnesium, singly or in various combinations; each solution also contained a quantity of a concentrated hatching-factor preparation free from inorganic material, at a strength 1/5 of its optimum to give scope for increased or decreased hatching. A single-cyst technique was used[5] and a logarithmic transformation for statistical analyses[6]. In general, we have found that chlorides of the monovalent ions had a depressing effect, that is, hatching was lower than in the hatching factor alone; with the chlorides of the divalent ions hatching was higher. There was also some evidence of antagonism. No emergence took place in the salt solutions without hatching factor.

In most of our experiments, all salt solutions have been equivalent osmotically to 2 m*M* potassium chloride, so that it has always been possible to compare the different metallic ions independently of any osmotic effect. But in some experiments, a series of different concentrations has been employed, always so that it was possible to compare iso-osmotic solutions of the different salts. In some cases, we have controlled the possible influence of osmotic factors on the performance of the hatching factor alone by the addition of an appropriate quantity of glycerol.

Particular attention has been paid to potassium and calcium ions, in view of their known effect on heart action. The results of a series of experiments are summarized in Fig. 1. Although carried out at different times during 1957, the experiments were sufficiently similar to justify combining their results for purposes of presentation, and, in the diagram, each point is a mean value based on a number of experiments. Most of the experiments were carried out at concentrations equivalent to 2 and to 0·2 m*M* potassium chloride, the values for higher and lower concentrations being based on fewer experiments. The line representing hatching factor alone is based on nine lots of cysts in five separate experiments, four with hatching factor alone, and five with glycerol added to bring them to various concentrations

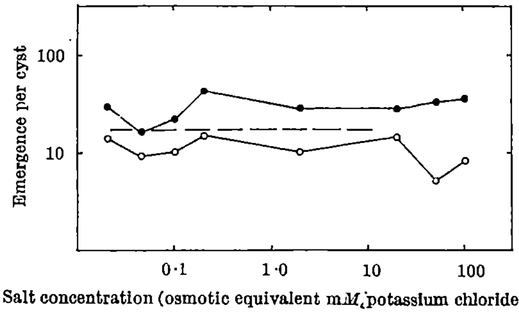

Fig. 1. Influence of potassium chloride and calcium chloride on hatching-factor activity. Values, being based on a logarithmic transformation, are essentially geometric means on a double log grid.

●—●, Hatching-factor + calcium chloride; — —, hatching-factor alone; O—O, hatching-factor + potassium chloride

covering the range of the diagram up to 20 m*M* potassium chloride: there were no significant differences among these results, and the dotted line is based on an over-all mean.

Salt concentration had little effect, emergence being fairly uniform over the 5,000-fold range of concentrations examined; but, clearly, emergence was higher in solutions of hatching factor containing calcium ions than in those containing potassium ions. Of the sixteen lots of cysts tested with potassium chloride and hatching factor in the various experiments, fifteen gave hatches lower than their appropriate control; for calcium chloride, thirteen out of sixteen gave higher values. In fact, potassium usually about halved hatching and calcium doubled it. Since, in general, larval emergence is proportional to log hatching factor concentration[7], the over-all increase in emergence between potassium-containing and calcium-containing hatching solutions is equivalent to increasing the concentration of hatching factor about twenty times.

There is chemical evidence that, like the cardiac glycosides, the hatching factor contains an unsaturated lactone group[8]; for this reason, and because of its cardiotonic activity, it was suggested that it might act by influencing ion transport[3]. The influence of ions on hatching-factor activity is consistent with this view: it derives additional support from the results of experiments with quinidine sulphate. Whether quinidine-like agents act on cardiac muscle by reducing permeability to potassium ions[9], or by acting directly on the carrier mechanism[10], it is agreed that they influence ion transport in some way. It is therefore particularly interesting that quinidine sulphate has a powerful effect on the activity of the hatching factor in the presence of potassium ions. The addition of 3×10^{-6} *M* quinidine sulphate to a hatching-factor solution had no significant effect on its activity, emergence being 44 larvæ/cyst in hatching factor alone and 39·5 with the drug added. In hatching factor + 2 m*M* potassium chloride, hatching was reduced significantly to 17·2; however, the addition of 3×10^{-6} *M* quinidine sulphate to this solution completely nullified the potassium effect, emergence being 43·7.

These experiments were all carried out with cysts from the same source and, in repeat experiments, reasonably consistent results were obtained. However, lack of the same consistency with cysts of different origin suggested that the ionic contribution of the cyst contents might be of importance; and a number of experiments have been carried out which suggest that this may indeed be the case. In the first, four lots of cysts were soaked in solutions of sodium chloride, potassium chloride, calcium chloride and magnesium chloride, respectively, all iso-osmotic with 2 m*M* potassium chloride; a further lot was soaked in distilled water. After a fortnight, they were washed, and then all stimulated with hatching-factor solution. At the end of a week, emergence from the cysts soaked in the salt solutions was about three times as high as emergence from the cysts soaked in water. A repeat experiment, using iso-osmotic glycerol instead of water for the control, gave similar results. The effect decreased with time, so that, in some cases, the final hatches did not differ significantly. However, most of our experiments were carried out with sub-optimal concentrations of hatching factor and there is evidence that, with stronger solutions, the initial response is so much higher that a larger total hatch results. The effect can also be reduced by soaking the cysts in water for two weeks, after the salt soaking; but in some experiments it persisted after this and even after more rigorous treatment. In one experiment, cysts were removed from the salt solutions after a fortnight, washed, and allowed to dry at room temperature. They were maintained air-dry at 23° C. for a fortnight, soaked for a further two weeks in distilled water, and then stimulated with hatching factor in the usual way. Emergence from the originally salt-soaked cysts was significantly higher than from the originally water- or glycerol-soaked cysts otherwise treated identically.

Experiments on the ionic pretreatment of cysts are not sufficiently advanced for us to speak with confidence of differences due to particular ions. But there is evidence that such differences may exist. In the experiment just described, although the hatches from all the salt-soaked cysts were higher than controls, the differences were highest in the case of potassium chloride and sodium chloride, and the effects were apparently more persistent. Experiments are still proceeding, and a full account will be presented in due course, but already it can be said that it is not improbable that some of the differences in the behaviour of cysts from different sources may be due to the ionic environment to which they have been subjected. Possibly this factor may be partly responsible for the differences between cysts from different sources to which Fenwick has directed attention[7].

The experiments on the influence of ions were only made possible by the gift of a sample of a hatching-factor concentrate free from inorganic material; for this we offer our grateful thanks to Dr. G. J. Janzen, of the Proefstation voor Aardappelverwerking, Groningen. The work forms part of a programme supported by a grant from the Nuffield Foundation, for which we should also like to express our gratitude.

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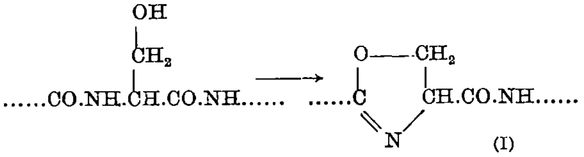
MECHANISM OF ESTERASE ACTION

Nature of the Reactive Serine Residue in Enzymes inhibited by Organo-Phosphorus Compounds

THERE is now overwhelming evidence[1] that the inhibition of cholinesterase, chymotrypsin and other esterases by di-*iso*propyl phosphorofluoridate and other organo-phosphorus compounds involves the phosphorylation of only one of the many serine residues present in the enzyme molecule. Serine itself does not react with di-*iso*propyl phosphofluoridate in aqueous solution[2], and there must be some special explanation for the exceptional reactivity of one of the serine residues in the sensitive enzymes. There are two obvious ways in which the reactivity of a serine side-chain may be enhanced: it may be influenced by some other side-chain (for example, histidine[1]) in its proximity, or it may be chemically modified.

One chemical modification of a serine side-chain to give a possibly more reactive grouping is cyclization to a Δ^2-oxazoline, (I):



The presence of Δ^2-oxazoline residues in intact proteins has been suggested before[3] and they have been postulated as intermediates in the N → O acyl migrations which occur when serine-containing peptides and proteins are treated with acid[4].

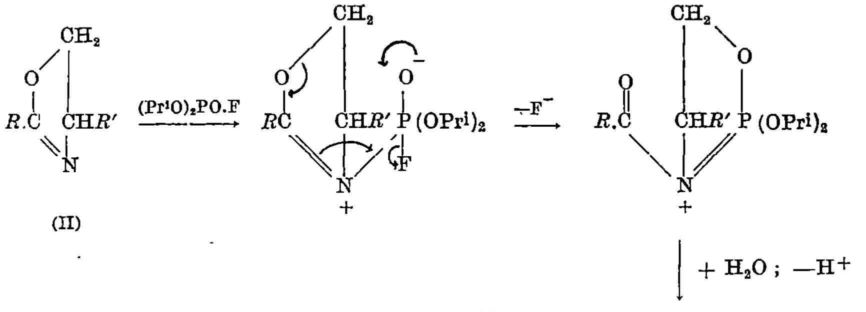


Fig. 1

We have, accordingly, studied the action of di-*iso*propyl phosphofluoridate in aqueous sodium bicarbonate at 37° on three representative Δ^2-oxazolines, namely, 2-methyl-Δ^2-oxazoline (II; R = Me; R' = H), 2-phenyl-Δ^2-oxazoline (II; R = Ph; R' = H), and 4-carbamoyl-2-phenyl-Δ^2-oxazoline (II; R = Ph; R' = —CO.NH$_2$). Although the last-named compound did not react, the two others did, the methyl compound more readily than the phenyl, giving products which yielded O-phosphoryl-ethanolamine (III; R' = H) on acid hydrolysis; control experiments showed that the reactions did not involve prior ring-opening to N-acyl-ethanolamines, followed by O-phosphorylation.

A reasonable course for the reaction is shown in Fig. 1. Our main argument, however, is not dependent on the validity of this mechanism.

As might be expected from the nucleophilic reaction of the oxazoline nitrogen postulated in the first stage, measurement of the basic strengths of the three Δ^2-oxazolines studied showed them to run parallel with the reactivity towards di-*iso*propyl phosphofluoridate, thus:

Δ^2-Oxazoline	Reactivity towards di-*iso*propyl phosphofluoridate	pK_a
2-Methyl-, (II; R = Me; R' = H)	++	5·5
2-Phenyl-, (II; R = Ph; R' = H)	+	4·4
4-Carbamoyl-2-phenyl-, (II: R = Ph; R' = CONH$_2$)	0	2·9

The decreases in basic strength observed on replacing a 2-methyl- by a 2-phenyl-group and on introducing an amide grouping at position 4 are expected consequences of the electron-attracting properties of the phenyl and amide groups.

It appears, from these results, that a Δ^2-oxazoline derivative will react with di-*iso*propyl phosphofluoridate in aqueous sodium bicarbonate, under conditions under which serine itself will not react, to give an O-phosphoryl-ethanolamine derivative, providing that it is sufficiently basic (pK_a not less than about 4). Whether or not a Δ^2-oxazoline peptide, as (I), will react under these conditions will depend on its basic strength; it seems likely that such a grouping will have a pK_a of just about 4, owing to the base-weakening effect of the adjacent peptide grouping, and may, therefore, be expected to react with di-*iso*propyl phosphofluoridate (and, presumably, also with analogous organo-phosphorus compounds) under such 'physiological' conditions.

We suggest, therefore, as a working hypothesis, that the singular serine residue present in the active centres of cholinesterase, chymotrypsin and other enzymes sensitive to di-*iso*propyl phosphofluoridate is, in fact, a Δ^2-oxazoline residue, as (I), and that it owes its unique reactivity to this chemical modification. Possible implications of this hypothesis for the mode of action of esterases are elaborated in the following communication.

Details of this work will be published elsewhere in due course; in the meantime, the experimental consequences are being actively pursued by one of us (H. N. R.) in collaboration with others.

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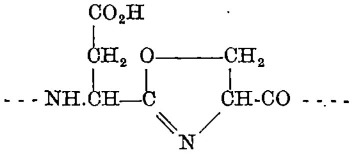
A Possible Mechanism of Action of Esterases inhibitable by Organo-Phosphorus Compounds

It has been shown that, in no less than six esterases (trypsin[1,3,5,6], chymotrypsin[1,2,5,7], red-cell cholinesterase[4], serum pseudo-cholinesterase[4], red-cell ali-esterase[4] and liver ali-esterase[4]), the uniquely reactive serine residue (-Ser*-), which is phosphorylated when the enzymes are inhibited by organo-phosphorus compounds, is situated in the sequence -Gly-Asp-Ser*-Gly-; it seems reasonable to suppose that this particular sequence must play an important part in the esteratic action of these enzymes. In this sequence, only the aspartic acid and serine side-chains are chemically reactive, and it thus seems likely that the key to the esteratic activity lies in the sequence -Asp-Ser*-. In the preceding communication, it has been suggested that the reactive 'serine' is, in reality, a Δ^2-oxazoline; if this is accepted, the structure of the key sequence is:



and it is the purpose of the present communication to show how this structure might operate as an esteratic centre.

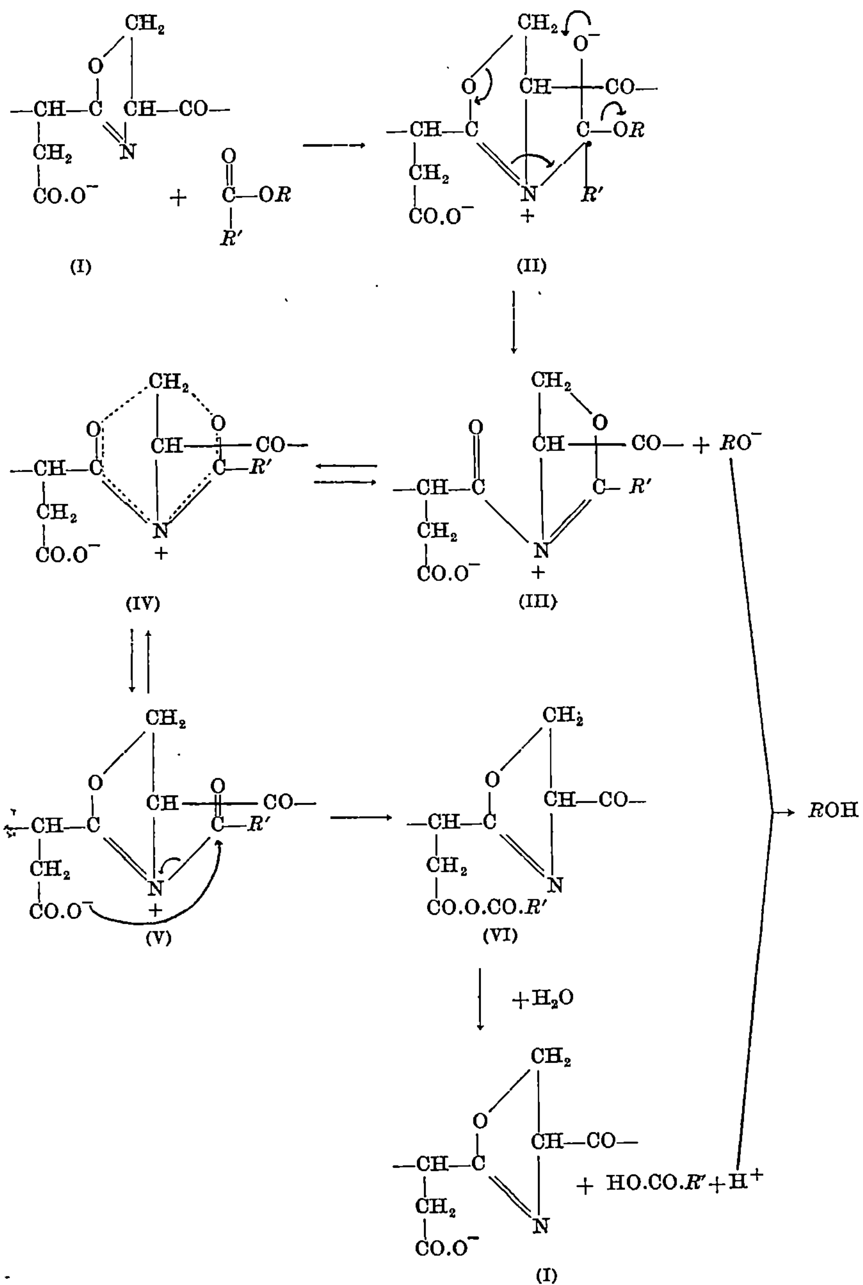


Fig. 1

The suggested esteratic process is shown in Fig. 1. The first stage involves nucleophilic attack of the oxazoline nitrogen on the ester to form the intermediate (II), which then is rearranged to the cation (III), with expulsion of the alkoxide anion; these two stages are precisely similar to those postulated in the reaction with organo-phosphorus inhibitors (preceding communication).

The cation (III) is in tautomeric equilibrium with its isomer (V), by way of the geometrically feasible transition state (IV). The essential difference between the carboxylic-ester substrates and the organo-phosphorus inhibitors resides in the difference in the position of equilibrium in the tautomeric system (III) $\rightleftarrows$ (V) and the analogous phosphorus system. In the former case, the equilibrium lies farther to the side of (V) and the carboxylic esters are substrates, whereas in the phosphorus case the equilibrium is more in favour of the analogue of (III), in consequence of which the organo-phosphorus compounds are inhibitory, undergoing the further stages of the esteratic reaction sequence only very slowly[8]. The postulated difference in the point of equilibrium in the two cases is supported by the observation that treatment of Δ^2-oxazolines with di-*iso*propyl phosphorofluoridates gives O-phosphoryl-ethanolamine derivatives (preceding communication), whereas carboxylic acid halides yield ethanolamine derivatives with the new acyl group attached to nitrogen[9].

In the next stage, the ionized aspartic acid side-chain, drawn by electrostatic forces to the neighbourhood of the positively charged nitrogen and so favourably placed to do so, attacks the carbonyl group of the $>\overset{+}{\mathrm{N}}.\mathrm{CO}.R'$ grouping. This process (compare the acylating properties of, *inter alia*, N-acyl-pyridinium salts[10], N-acetyl-imidazole[11] and N-phospho-imidazole[12]), in which the charges are neutralized, leads to the anhydride (VI), in which the acyl residue is now attached, temporarily, to the aspartic acid side-chain. It is noteworthy that, in strongly acid solution, when the aspartic acid side-chain will not be ionized, it is possible to isolate an acetyl-chymotrypsin from the products of the action of chymotrypsin on p-nitrophenyl acetate[13]; this acetyl-chymotrypsin behaves as an acetylating agent, as the protonated form of V ($R' = \mathrm{Me}$) might well be expected to do.

Finally, the anhydride (VI) undergoes hydrolysis, possibly assisted by a suitably placed histidine side-chain in an adjacent fold of the peptide chain, regenerating the enzyme (I), the acid, HO.CO.R', and hydrogen ion, which combines with the alkoxide ion liberated in the second stage, so completing the cycle. It will be seen that the suggested mechanism requires the liberation of the alcohol, ROH, from the ester, R'.CO.OR, undergoing hydrolysis, to precede the liberation of the acid, $R'.\mathrm{CO_2H}$; this is in agreement with the experimental finding[14] that, in the hydrolysis of p-nitrophenyl acetate by chymotrypsin, a relatively rapid liberation of p-nitrophenol is followed by a much slower liberation of acetic acid.

The mechanism of esterase action advanced above is in agreement with many previous experimental findings and has the advantage of affording an interpretation of the existence of a common amino-acid sequence around the reactive 'serine' in many esterases, which has already been commented on, but not interpreted, by others[4,15]. Whether or not it eventually proves to be valid, it does at least suggest further experimental studies, some of the more obvious of which will be undertaken in these laboratories.

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SUBMICROSCOPIC STRUCTURE OF ELASTIC FIBRES AS OBSERVED IN THE POLARIZATION MICROSCOPE

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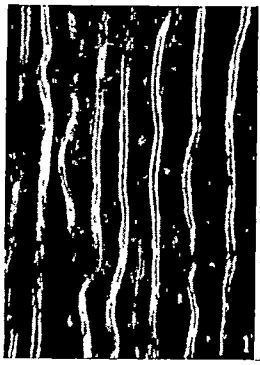
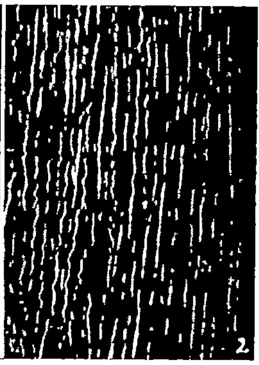
ELASTIC fibres are usually considered to be isotropic, and positively birefringent only on stretching[1]. However, in thin sections of unstretched material of human aorta and ox ligamentum nuchæ mounted in Canada balsam, I have found that they invariably show positive birefringence with retardations of about 8 mμ and 18 mμ, respectively. In a previous communication[2] I have shown that this positive birefringence of the elastic fibres in the human aorta changes into negative birefringence with retardations of about 16 mμ, when the sections are mounted in aniline after fixation in formalin, alcohol, Bouin, or Carnoy, dehydration of the deparaffinized sections in absolute alcohol, and clearing in terpineol or xylol (for further details see ref. 2).

The elastic fibres are slightly negatively birefringent already in a mixture of aniline (20 per cent) and terpineol, showing a refractive index, n, of 1·500 in an Abbé refractometer. Thus the negative birefringence of the elastic fibres in aniline cannot be regarded as being due to the relatively high refractive index of aniline ($n = 1{\cdot}58$), but rather as the optical evidence of its orientated adsorption to a structural component of the elastic fibres arranged longitudinally.

The depression by aniline to isotropy of the positive birefringence of the collagen fibres in the media of the aorta also suggests an orientated binding of aniline to the collagen fibres. Furthermore, in media with relatively high refractive indices obtained by mixing bromphenol ($n = 1{\cdot}57$) and monobromnaphthalene ($n = 1{\cdot}66$) there is no change of the positive birefringence of the elastic fibres to negativity.

The elastic fibres of the aorta of children show an axial isotropic band in aniline (Fig. 1) which, like that seen in some plant fibres[3], could be regarded as optical evidence of a submicroscopic spiral texture resulting from the compensation of the effects of the coiled filaments at their crossings at right angles in the fibre axis. Also, in aniline the elastic fibres of the ligamentum nuchæ show a broad axial compensation band as optical evidence of their spiral submicroscopic structure. These findings are in agreement with the earlier electron microscopic observation of a spiral texture of the elastic fibres





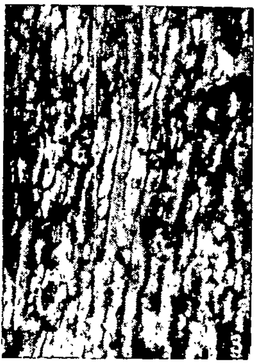


Fig. 1. Paraffin section of the aorta of a newborn infant mounted in anilin. The elastic fibres show intensive negative birefringence with an axial isotropic band

Fig. 2. Aorta of an adult. After treatment with testicular hyaluronidase for 2 hr. and staining with toluidin blue-ferricyanide at pH 4·0. The elastic fibres show intensive negative birefringence

Fig. 3. Aorta of an infant. Phenol reaction. The elastic fibres show slight negative birefringence with a poorly visible darker axial compensation band. They are surrounded by collagen fibres of stronger negative birefringence

in the ligamentum nuchæ and the skin[4]. With age the axial compensation band becomes thinner or disappears, which is probably due to an elongation of their inner spiral texture.

In recent studies with a new anisotropic staining method (buffered toluidine blue solutions at pH 7·0–2·6, followed by treatment with 5 per cent ferricyanide solution) I have found that, as a sign of their submicroscopic fibrillary structure, not only the mucoid components of the connective tissue ground substance[5] but also the elastic fibres of the human aorta show negative birefringence in green, yellow and red light, while the latter also displays isotropy in blue light, and anomalous colours ranging from dark blue to greenish-yellow, depending on the amount and sign of compensation. Thus, the elastic fibres stained with toluidine blue exhibit an optical behaviour similar to that of the collagen fibres similarly stained, which has recently been shown by Brewer[6] to be the result of an orientated adsorption of the dye molecules on the collagen fibres with their light-absorbing bonds at right angles to the fibre axis. The collagen fibres gave their staining reaction with toluidine blue above pH 4·1. However, I found that, like the acid mucopolysaccharides of the aortic media, the elastic fibres showed anisotropic staining with toluidine blue ferricyanide in regions more acidic than those of the collagen fibres. Thus the anisotropy of the toluidine blue-stained elastic fibres might be interpreted as the result of an orientated binding of the dye molecules on the structural pattern of the mucoid components in the elastic fibres.

It is known that the elastic fibres in the aorta of the newborn are faintly basophilic[7]. That is why, when stained with toluidine blue, they show only weak anisotropy. But their anisotropic staining is markedly enhanced after pretreatment with potassium permanganate (as used in the silver impregnation techniques), which renders the elastic fibres and other tissue elements more basophilic by increasing the number of negatively charged side-groups on the substrates. This also applies to the faintly basophilic elastic fibres in the skin and in ox ligamentum nuchæ. It is interesting that, after treatment with permanganate, the enzymatic susceptibility to elastase (kindly supplied by Prof. I. Banga of Budapest) of the elastic fibres of human aorta and ox ligamentum nuchæ, measured by the time of their dissolution, was more than 100 times that of the controls.

In view of the structural complexity of the elastic fibres, evidence was sought by polarization microscopy bearing on the question of the possible collagen-like nature of the filaments demonstrated in elastin by electron microscopy[8]. In this connexion it is significant that the elastic fibres invariably change their positive birefringence to negative birefringence in sections mounted in phenol. In view of the high specificity of Ebner's phenol reaction for collagen[9]—given not only by mesenchymal but also by ectodermal (cuticular, lens capsule) collagens and by the collagen fibrils reprecipitated *in vitro*—it seems reasonable to assume that the protein filaments embedded in the matrix substance of the elastic fibres are in close structural relation to collagen-type proteins.

Polarization microscopy thus provides the possibility of distinguishing in the elastic fibres two structural components: a protein demonstrable by the phenol reaction, and a mucopolysaccharide demonstrable by the toluidine blue ferricyanide method, both being present in a longitudinal or spiral arrangement. However, these two methods cannot be applied simultaneously to the same preparation. Toluidine blue-stained fibres when mounted in phenol lose their stain and show only the effect of the phenol reaction. It seems probable that close structural interrelationships between the two components and steric hindrances inhibit the simultaneous binding of the two components on the same structural basis.

The structural pattern of the elastic fibres suggested on the basis of these polarization microscopic findings is in good agreement with Hall's[10] model, which is based on electron microscopic and chemical observations of the enzymatic dissolution process of elastin. However, polarization microscopy has shown that, apart from their inner spiral architecture, a considerable portion of the mucoid component of the elastin fibres is not amorphous but longitudinally orientated along the fibres. This may possibly result from an interaction of the mucoid component with the protein filaments arranged longitudinally.

A more detailed account of these observations will be published elsewhere.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Ferromagnetism of Meteorites

THE aim of this communication is to describe some preliminary results on the magnetic behaviour of some stony meteorites, namely, Allais, Cold Bokkeveld and Orgueil. Paramagnetic resonance absorption has been used in order to be able to investigate ferromagnetic resonance and eventually paramagnetic particles or free radicals at the same time. These were not unexpected on account of the relatively high content of organic material of the selected meteorites[1]. The apparatus used was a Varian X-band microwave spectrometer. In no case was a sharp electron spin resonance observed, which seems to indicate that paramagnetic species are not present in significant concentrations. Instead a broad line occurred, which is presumed to arise from ferromagnetic resonance. The location of the maxima and the line-widths between the inflexion points are shown in Table 1.

Table 1

Name	Max. H_0 (œrsteds)	Line widths (œrsteds)
Allais	3,100	2,320
Cold Bokkeveld	3,100	2,460
Orgueil	3,100	2,250

The spectroscopic splitting factor (g), deduced assuming a random distribution for the crystallites, amounts to 2·19. This is not in disagreement with the corresponding values observed for nickel magnetite[2] and ferrites[3]. If the results of the elemental chemical analyses[4] are interpreted in terms of mineral compounds, it may be inferred that these substances are present.

It is to be noted that we have now at our disposal an objective method for studying the evolution of ferromagnetic content through the group of stony meteorites. Further research on this problem is now in progress.

We are greatly indebted to Father J. Junkes, director of the Spectroscopic Laboratory of the Vatican Observatory, for the loan of specimens of meteorites. Our thanks are also due to Varian Associates for putting a spectrometer at our disposal.

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Removal of Gases in High Vacuum Systems by Metal Abrasion

CHEMICAL reaction with metal films (gettering) is a well-known process for the removal of free gas in vacuum devices. However, removal can cease once a thin layer of reaction product has formed. Thus the layer of oxide which forms on fresh aluminium surfaces at room temperature is protective[1], and so are the layers of oxide that form on the initially reactive metal, titanium[2]. Similar protective layers of compounds other than oxides also occur—see, for example, a recent review[3].

In order to overcome such limitation upon capacity for taking up gas, pumps have been designed[4] in which titanium is evaporated continuously, to provide films having fresh surfaces highly reactive with gas molecules. However, to evaporate titanium fast enough for the pump to take up gas at a useful rate (say, a few litres/μsec.), the metal must be raised above its melting point (1,670° C.), as vapour pressure data[5–7] show. Unfortunately, at such high temperatures, titanium is so reactive that there are few suitable materials from which to make hearths for holding the molten metal.

As alternative to overlaying the protective reaction products with freshly evaporated titanium, a promising idea is abrasion of the oxide, or similar layer, to expose the fresh titanium beneath. Only a very thin layer of oxide has to be removed, so scratching rather than, say, turning seems appropriate. Some preliminary experiments demonstrating the reaction of gas with a freshly abraded surface of titanium will now be described.

A trough was made from sheet titanium and in it were put a few lumps of some suitable abrasive, such as 'Carborundum' (Carborundum Co., Ltd., Manchester 17), or some pieces of an old metal file. The titanium trough was mounted in a glass bulb to which was attached both an ionization gauge for measuring the pressure of free gas and a porous ceramic appendage through which fresh free gas could be introduced at will from a surrounding jacket that could either be filled with known gases or evacuated. As a start the whole device was evacuated, baked to remove water vapour, and sealed off containing free gas at some pressure less than 10^{-6} mm. mercury. Then gas was admitted through the porous ceramic tube just fast enough to maintain the pressure at, say, 10^{-4} mm. mercury, in spite of the reaction of the gas with the hot tungsten filament and some loss to the walls (clean-up). (With oxygen the loss by reaction with the filament is appreciable—see, for example, ref. 8—but with nitrogen is negligible). When the lumps of abrasive were shaken about in the trough of titanium, or the bits of file dragged back and forth therein by means of an external magnet, the pressure fell rapidly, in less than a minute, to 10^{-6} mm. mercury. By admitting more fresh gas this fall could be demonstrated repeatedly in any particular tube. After many runs using lumps of abrasive so much powdered debris covered the bottom of the trough that gas was not taken up as readily as at the start. But in such a tube the previous best performance was maintained by dragging about the bits of file with a magnet: for in this way loading upon, and mechanical damage to, the titanium was greater.

Since air contains about 1 per cent of argon, it might have been expected that it would be impossible to reduce the pressure again below about 10^{-6} mm. mercury, and that after each successive admission of fresh gas the background pressure of free argon would increase. But this did not happen. It is true that the most rapid fall of pressure upon shaking and scratching occurred for the first hundredfold reduction; but it continued thereafter more slowly, while the ionization gauge was run. Such slow cleaning-up of the last 1 per cent remnant of air occurs probably through an exchange of argon with other gases hidden in the walls[9] and electrodes[10] or by absorption as in getters protected by argon atmospheres[11,12]. A more rapid removal of argon would be essential for improving the performance of any abrasion pump required to remove air entering continuously through leaks, as in demountable equipment; but the present form is adequate for removing gas coming from virtual leaks in sealed-off tubes like those used here.

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Anomalous Dissociation of Molecular Hydrogen by Electron Impact

AN electron colliding with a hydrogen molecule can raise it to an excited state from which it may return to the ground-state by dissociating into atoms with or without emission of a light quantum. Numerous experiments with electrons up to about 30 V. energy have been carried out, but their interpretation was of heuristic value only. Neither the critical potentials for the various processes nor the dependence of the probability of a process on the electron energy was known with sufficient accuracy, and even the relative contribution of the various processes to dissociation was a matter of conjecture.

The problem was therefore attacked anew, both experimentally and theoretically. Recent observations by Corrigan and von Engel[1] show that the main contribution to dissociation comes from raising the molecule to the repulsive lowest triplet state, from which it dissociates into two hydrogen atoms in the ground-state, each with kinetic energy of a few volts; that is, no light emission occurs. This transition sets in theoretically at about 8·8 V., though earlier observations suggested an onset potential of 11–11·5 V.

Present theoretical work provides a possible explanation of certain anomalies in the region of the onset potential. In addition, there is some measure of quantitative agreement between the theoretical results of the probability of the above transition and new measurements with electron swarms.

A variational method was used to calculate the inelastic scattering cross-section associated with the transition ${}^1\Sigma_g^+ \rightarrow {}^3\Sigma_u^+$, and 120 values of the cross-section have been obtained, that is, 20 values with a final energy of the electron from 0 to 18-V. at intervals of 0·8 V. and six values with an energy loss of 8·6–15·5 V. at 1·4-V. intervals.

To obtain the dissociation cross-section as a function of the initial energy of the electron, these values should be averaged over the vibrational motion. However, if it is assumed that the result of this would be to select effectively the curve corresponding to energy loss of about 10–10·5 V., that is, one at the centre of the Franck–Condon range, then useful preliminary results can be found without detailed averaging.

All the six curves obtained have three features in common: first, in the range 0–0·8 V. above threshold, the cross-section is very small; it then rises in the range 0·8–1·7 V. above threshold by a factor of 200 or more and yet not giving values greater than the theoretical maximum which follows from the conservation of charge. Secondly, from 1·7 to 5 V. above threshold, the cross-section drops to a minimum value; and then, thirdly, in the range 5–18 V. above threshold it rises to a second maximum and falls off again.

The following table gives the values of the cross-section for an energy loss of 10 V., the critical potential for the chosen fixed interatomic distance between the nuclei ($\pi a_0^2 = 8\cdot8 \times 10^{-17}$ cm.^{2}):

Initial electron energy (V.)	10	10·8	11·7	12·5	15·8	16·7	21·7	22·5	26·7
Cross-section (πa_0^2)	0	$2\cdot4\times10^{-3}$	0·7	0·52	0·19	0·19	0·33	0·33	0·22

If the cross-section curve for 10 V. energy-loss is representative, then the theory predicts that the cross-section is very small up to 10·8 V. and rises by a large factor of order 100 to a maximum at about $11\cdot9 \pm \frac{1}{4}$ V. (since the probable energy-loss is between 10 and 10·5 V.). Because of the extremely small cross-section for the first 2 V. above the true onset at 8·8 V., we find what might be called an 'effective onset potential' between 10·8 and 11·3 V. which would be observed by experimenters using an apparatus of limited sensitivity. This result is in agreement with the earlier observations cited above. Whereas the anomalous onset has been speculatively explained[2] as entirely due to the vibrational averaging, it is now thought that the anomaly can be resolved into an electronic and a vibrational contribution both of the same order of magnitude.

Recently, Corrigan and von Engel[1] have measured dissociation coefficients in hydrogen, that is, the number of dissociations per centimetre of path in the field direction using an electron swarm in a uniform electric field of magnitude less than or equal to 100 V./cm. at 1 mm. mercury pressure. If the energy distribution of the electrons in the swarm is assumed to be Maxwellian, then the above theoretical results are in accord with the rate of dissociation observed.

I wish to acknowledge the guidance of Prof. H. S. W. Massey in my calculations.

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Anthocyanins of Blood Oranges

THE fleshy endocarp of the blood orange, a variety of sweet orange, *Citrus sinensis*, contains a water-soluble red pigment which Matlack[1] showed to be anthocyanin in nature.

Factors influencing the production of anthocyanin in Sicilian varieties have been discussed by Carrante[2]; estimates of the amounts found in the juice have been made by Ajon[3]; and Patanè has published a method for its partial isolation[4]. However, no formal identification has apparently yet been made. Evidence is presented here to show that cyanidin-3-glucoside is the major pigment of the Moro variety of the blood orange, with a second pigment, probably delphinidin-3-glucoside, as a minor component.

Extraction of the pulp (2 kgm.) with methanol containing 1 per cent hydrochloric acid was followed by precipitation of the pigment as the lead complex. The precipitate was decomposed with hydrochloric acid, and the recovered pigments were taken up in butanol to which 4 volumes of benzene were then added. The solution was extracted with one volume of 1 per cent hydrochloric acid. The difficultly soluble hesperidin remained in the organic layer from which it was slowly deposited on standing. Purification was effected by cellulose column chromatography with the organic phase of butanol/$2N$ hydrochloric acid as solvent, used for separation of the black currant anthocyanins[5]. Three bands appeared on the column as elution proceeded: a rapidly moving brown band, a scarlet band, and a small slowly moving mauve band. The eluate was collected in 50 ml. fractions and a graph of the optical density at 535 mμ against fraction number indicated that the third pigment represented only about 1 per cent of the total.

The pigment in the first band was concentrated by precipitation as the lead complex and the other two by absorption on a second cellulose column as already described[5]. Paper chromatography of these concentrates and their hydrolysis products gave the following results, confirmed where possible by absorption spectra and colour tests.

(*a*) The pigment in band 1 consisted largely of red-brown material running at all times with the solvent front. Also present were traces of an anthocyanidin, chromatographically identical with cyanidin, obtained by hydrolysis of the second strawberry pigment, cyanidin-3-glucoside[6]: R_F in butanol/$2N$ hydrochloric acid, 0·75; in Forrestal solvent, 0·49.

(*b*) The pigment in band 2, amounting to about 95 per cent of the total, was a cyanidin derivative, the aglycone obtained on hydrolysis by treatment with 5 per cent perchloric acid for 30 min. at 50° C. being chromatographically identical with cyanidin. The anthocyanin behaved as a 3-glycoside, co-chromatographing with the second strawberry pigment in four solvent systems: R_F in butanol/$2N$ hydrochloric acid, 0·26; in butanol/acetic acid/water, 0·38; in *m*-cresol/acetic acid/water, 0·34; in Forrestal solvent, 0·74.

(*c*) The pigment in band 3 was a delphinidin derivative, and chromatographed as a 3-glycoside in the four solvent systems given above, with R_F values of 0·16, 0·21, 0·16 and 0·65, respectively. The aglycone obtained on acid hydrolysis was chromatographically identical with delphinidin, the hydrolysis product of delphin, obtained from blue delphiniums and purified by column chromatography: R_F in butanol/$2N$ hydrochloric acid, 0·45; in Forrestal solvent, 0·28.

(*d*) Glucose was the only sugar present in the hydrolysates from the two glycosides, co-chromatography with glucose producing no separation in three solvent systems: R_F in *n*-collidine, 0·38; in ethyl acetate/water/pyridine (2 : 2 : 1), 0·30. R_x in water-saturated *n*-amyl alcohol, 0·42 (R_x of xylose, 1·00). Galactose in these solvent systems gave values of 0·35, 0·25 and 0·33, respectively.

From the hydrolysate of the main pigment an osazone was prepared, melting point 205° C.; no depression when mixed with authentic glucosazone, melting point 207° C.; but depressing the melting point of authentic galactosazone (197° C.) by 15–20 deg.

These results identify the main pigment as cyanidin-3-glucoside, confirmed by the determination of the aglycone : glucose ratio, using the method and the molecular extinction coefficient given by Nordstrom[7].

Identification of the second glycoside as delphinidin-3-glucoside is based on its behaviour on the paper chromatogram, partition between solvents, colour tests, and chromatographic behaviour of the sugar moiety.

These observations apply specifically to the Moro variety. The main pigment of three other varieties, Tarocco, Florida and Ruby Red, is indistinguishable chromatographically from that of the Moro, and no major varietal difference seems likely in anthocyanin pigmentation.

The fruit was provided by Dr. W. P. Bitters, University of California, Riverside.

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Incorporation of Radioactive Sulphur by *Thiobacillus thioparus*

IN the course of our investigations on the metabolism of sulphur in the autotrophic bacteria *Thiobacillus thioparus* we have found that this micro-organism metabolizes only the outer sulphur atom of thiosulphate. The inner sulphur atom probably does not enter the bacterial cell and is left in the medium as a sulphate ion[1]. We carried this investigation further with thiosulphate labelled in the outer position with sulphur-35 ($Na_2O_3S^{35}S$), tracing the pathway of the radioactive sulphur in the bacterial cells.

The pool of free amino-acids and related compounds were investigated in the following manner: the ethanol extract from a culture of *Th. thioparus* which had been incubated for 24 hours with radioactive thiosulphate was separated by paper electrophoresis and chromatography, after which autoradiograms were made. We proved that radioactive sulphur is incorporated into cysteine, cystine and methionine as well as in cysteic and cysteinesulphinic acids. A few other radioactive spots were also established. One of these sulphur compounds was identified as α-thiooctanoic acid, by its R_F value and from the results of microbiological tests with *Streptococcus faecalis*[2].

The whole cells of bacteria incubated in this way were hydrolysed, and the product was fractionated by paper electrophoresis and chromatography. All typical amino-acids were demonstrated in the hydrolysate; dicarboxylic acids, alanine, threonine, glycine, serine and leucine were present in particularly large amounts. We found the same sulphur amino-acids as in the ethanol extract. Besides these amino-acids some unidentified sulphur compounds were found.

Definitely different results were obtained during investigation of the alcohol extract and whole-cell hydrolysate, when the bacteria were incubated with radioactive thiosulphate for 1–10 min. only. The chromatographic analysis in this case, of course, gives the same results as for bacteria incubated with thiosulphate for 24 hours; the difference is in the autoradiograms in which no ninhydrin-positive substance has any measurable radioactivity. Instead of the known radioactive sulphur amino-acids, a radioactive spot appears corresponding to compounds which do not migrate electrophoretically at *p*H 2·7, and which do not stain with ninhydrin. The radioactivity of these substances increases with the duration of incubation. The unidentified substances which give rise to this spot are a mixture of at least two compounds which can be separated chromatographically in the system *n*-butanol—acetic acid—water (5 : 4 : 1), the R_F values of which are 0·23 and 0·52.

This and former experiments[1] lead us to suggest that the outer sulphur atom of thiosulphate reacts with some organic acceptor in the bacterial cells, forming a compound (not yet identified) detectable during the early stages of incubation with thiosulphate. This compound represents one of the steps in the metabolism of sulphur in the cell. The hypothetical organic acceptor probably reacts not only with the sulphydryl group of thiosulphate but also with the same group in other sulphur compounds. This idea arises from our experiments on *Th. thioparus* incubated in a medium containing cysteine labelled with sulphur-35. The culture of *Th. thioparus* does not develop when the sole source of oxidizable sulphur is cysteine; it only does so in the presence of thiosulphate. When *Th. thioparus* is incubated in a medium with unlabelled thiosulphate and labelled cysteine it is possible to demonstrate that after some time the alcohol extract and whole-cell hydrolysate contain the same radioactive sulphur compounds as were found after incubation with radioactive thiosulphate alone. In the medium, radioactive, elementary sulphur and radioactive sulphate ions also appear as oxidation products of cysteine sulphur. These radioactive substances cannot be solely the products of non-biological reactions between cysteine and thiosulphate, because such reactions would give rise to other compounds (following communication); nor do they originate from an isotope exchange reaction.

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Reactions of Thiosulphate with Cysteine

During investigations of the metabolism of sulphur compounds in autotrophic bacteria and in higher animals, it was observed that thiosulphate reacts spontaneously with cysteine. This reaction has been studied fairly extensively, revealing some facts which may be of interest for understanding the behaviour of thiosulphate *in vitro* and *in vivo*.

The experiments reported below were performed in an apparatus consisting of a reaction vessel with a side-arm connected to an absorption vessel by a ground-glass joint. A stopcock in the joint connected the apparatus to a vacuum pump and the reactions were performed *in vacuo*.

Hydrogen sulphide was trapped by a suspension of cadmium hydroxide. Chromatograms were developed in acetic acid in phenol saturated with an aqueous solution containing 6·3 per cent sodium citrate and 3·7 per cent sodium dihydrogen phosphate. The spots were detected by ninhydrin staining. All reagents were of analytical grade.

(1) Thiosulphate (1 m.mole or more) was mixed with a solution of cysteine (1 m.mole in 5 ml.) suitably buffered with carbonate or phosphate to *p*H 7–7·4, and the mixture was left overnight at room temperature. The appearance of yellow cadmium sulphide in the absorption vessel indicated that hydrogen sulphide was evolved; at the same time a white substance was precipitated.

The hydrogen sulphide originates solely from the outer sulphur of thiosulphate, as can be shown by experiments with radioactive thiosulphate or cysteine. The hydrogen sulphide produced was radioactive only when thiosulphate labelled with sulphur-35 in the outer position ($Na_2O_3S^{35}S$) was used; it was completely inactive when the radioactivity was initially in the cysteine sulphur.

The white precipitate was identified as cysteine, but the amount represented only part of the cysteine originally present. This was interpreted as meaning that some of the cysteine was converted to a different compound. In order to study this problem the solution was investigated chromatographically. On the chromatograms there was only one well-marked ninhydrin-positive spot, with R_F value 0·04–0·05. (In the experimental conditions cysteine was deposited in too small a quantity to give a coloured spot). This spot was identical with that given by cysteine-sulphonic acid prepared by Clarke's method[1].

The formation of hydrogen sulphide, cystine and cysteine–sulphonic acid as products of the reaction between thiosulphate and cysteine can be formulated as follows:

$$R - SH + {}^{-}S - SO_3^{-} \rightarrow R - S - SO_3^{-} + HS^{-}$$

$$R - S - SO_3^{-} + R - SH \rightleftharpoons R - S - S - R + HSO_3^{-}$$

where R represents the aminopropionic radical $-CH_2.CHNH_2.COOH$.

Glutathione and dimercaptopropanol react also with thiosulphate with production of hydrogen sulphide, but the other products were not investigated.

(2) When the solution resulting from the reaction described above was warmed for several hours at 60° C., the precipitate of cystine dissolved, and the chromatograms of the solution exhibited, besides the cysteinesulphonic acid spot, another spot with R_F 0·08–0·1. This spot is supposed to be due to a new

compound, which may be called cysteinethiosulphonic acid: $R\text{—S—S—SO}_3\text{H}$. Its formation can be explained by the reaction:

$$R\text{—S—S—}R + {}^-\text{S—SO}_3^- \rightarrow R\text{—S—S—SO}_3^- + R\text{S}^-$$

This supposition is supported by the fact that a warmed solution of cysteine and thiosulphate tested chromatographically also gives two spots located in exactly the same positions as those described above. The second reason is that a compound with R_F value 0·08–0·1 is formed during the oxidation of a cysteine and thiosulphate mixture with iodine. In this case there are three possible parallel reactions:

$$2R\text{—SH} + \text{I}_2 \rightarrow R\text{—S—S—}R + 2\text{H}^+ + 2\text{I}^-$$
$$2\,{}^-\text{S—SO}_3^- + \text{I}_2 \rightarrow {}^-\text{O}_3\text{S—S—S—SO}_3^- + 2\text{I}^-$$
$${}^-\text{S—SO}_3^- + R\text{—SH} + \text{I}_2 \rightarrow R\text{—S—S—SO}_3^- + \text{H}^+ + 2\text{I}^-$$

The third reaction produces cysteinethiosulphonic acid, which can be identified chromatographically.

(3) The reaction of cysteine with tetrathionate is connected with the facts described above. When solutions of these compounds (mM : mM) were mixed together a white precipitate was quickly formed, which was identified as cystine, but other products are also formed. Curiously enough, the chromatograms of the solution revealed the existence of three spots located near one another. The two lower spots corresponded to those of cysteinesulphonic acid and cysteinethiosulphonic acid, the third presumably belongs to a compound which may be called cysteinedithiosulphonic acid, $R\text{—S—S—S—SO}_3\text{H}$. The reaction which led to the formation of this acid may be formulated:

$$R\text{—SH} + {}^-\text{O}_3\text{S—S—S—SO}_3^- \rightarrow R\text{—S—S—S—SO}_3^- + \text{HSO}_3^-$$

If the formulations of the reactions described above are correct, a way is opened for the synthesis of a new class of compounds which may be called cysteinepolythiosulphonic acids. Further studies are in progress.

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Inhibition of Cholinesterase Hydrolysis of Dihydromurexine by Lysergic Acid Diethylamide and its 2-Bromo Derivative: a Selective Relationship

PREVIOUS investigators have shown that human plasma cholinesterase is strongly inhibited by both lysergic acid diethylamide (LSD) and its 2-bromo derivative (BOL). The cholinesterases of other species were less sensitive to the effects of both these substances[1-3]. Recent reports described certain newer choline esters, namely, imidazoleacrylylcholine[4,5] (murexine), imidazoleacetylcholine[6] and imidazolepropionylcholine (dihydromurexine) which are hydrolysed most readily by human plasma cholinesterase[7-10]. These observations have led us to evaluate the possible relationship between cholinesterase inhibition by lysergic acid diethylamide and BOL and cholinesterase hydrolysis of dihydromurexine. Dihydromurexine was chosen as the model substrate because it is the most active of the three esters.

Table 1. HYDROLYSIS OF BUTYRYLCHOLINE AND IMIDAZOLEPROPIONYLCHOLINE BY SERA OF SEVERAL SPECIES AND THE INHIBITORY EFFECTS OF LYSERGIC ACID DIETHYLAMIDE

1 ml. of 1 : 10 dilution of serum; 0·5 or 1 ml. of 0·1 M phosphate buffer pH 7·2; 0·5 ml. of inhibitor to give a final concentration of 8×10^{-6} M; 0·5 ml. of butyrylcholine (800 μgm./ml.) or 0·5 ml. of equivalent amount of dihydromurexine; temperature, 37° C.; incubation time, 10 min.; total volume, 2·5 ml. Choline esters were measured by Hestrin's method (ref. 11)

Substrate	Butyrylcholine		Dihydromurexine	
Species \ Inhibitor	−LSD	+LSD	−LSD	+LSD
Cat	*H*	*H*	—	—
Dog	*H*	*H*	—	—
Guinea pig	*H*	*H*	—	—
Mouse	*H*	*I*	*H*	*I*
Human	*H*	*I*	*H*	*I*

H, 90–100 per cent hydrolysis of substrate; *I*, 90–100 per cent inhibition; —, no hydrolysis of substrate.

Table 1 indicates that though all the sera tested hydrolysed butyrylcholine, only mouse and human sera hydrolysed dihydromurexine under the conditions of these experiments. Moreover, only mouse and human serum cholinesterases were inhibited by lysergic acid diethylamide. Similar findings were obtained employing BOL as the inhibitor.

Further experiments have shown that both mouse and rat brain homogenates hydrolyse butyrylcholine. However, the pseudocholinesterase of mouse brain differed from that of rat brain in two respects: (1) mouse brain cholinesterase catalysed the hydrolysis of dihydromurexine, and (2) this enzyme was strongly inhibited by lysergic acid diethylamide or BOL. Rat brain cholinesterase did not display either of these properties. Thus, in all cases tested so far, a potent inhibition of cholinesterase by lysergic acid diethylamide or BOL was observed only when the enzyme was capable of hydrolysing dihydromurexine.

These results suggest that a specific enzyme–substrate relationship (ability of some cholinesterases to hydrolyse dihydromurexine) is the basis for the selectivity displayed by lysergic acid diethylamide and BOL towards various cholinesterases. The identification and evaluation of other choline esters may aid in clarifying this observation.

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Radiometric Titrations with Complexons

Among the reactions commonly used in volumetric work, only two are suitable for radiometric titrations: (*a*) reactions which result in combinations which are only very slightly soluble[1,2]; (*b*) reactions which result in complexes[3].

At first, precipitation reactions were used, one of the reactants being labelled with a radioactive isotope. The precipitate resulting from titrations was separated from the solution by filtration or centrifugation and the equivalence point was determined by measuring the activity of the solution. Thus, halides were determined with radioactive silver; manganese, uranium, thorium, beryllium and zirconium with radioactive phosphate; thallium with tetraphenylboron, etc. (*loc. cit.*).

I. M. Korenman[3] and F. G. Duncan *et al.*[4] introduced complexing reactions into radiometric titrations. Zinc, mercury and cobalt were determined by using dithizone as a complexing agent. The reaction product was separated from the solution, using the solubility of dithizone and its complexes in carbon tetrachloride (extraction). The same authors also proposed a non-isotopic tracer method, which consists in adding a radioactive isotope of another element (for example, cobalt-60) which may react with the complexing or precipitating agent only after the quantitative reaction of the cation under study has taken place.

This procedure has great advantages because it permits the choice of a convenient radioactive isotope and the determination of many cations with the same radioactive isotopes.

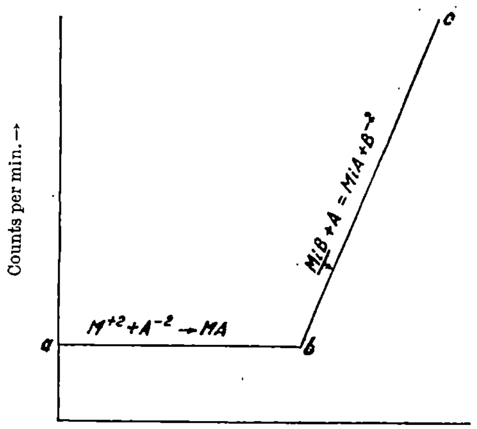
We have devised a radiometric titration depending on complexing reactions; the equivalence point is found, using a radioactive indicator in heterogeneous phase. The following procedure was employed: a cation, M^{2+}, was titrated with a complexing agent A^{2-}, and a precipitate containing a radioactive cation ($M_i{}^*B$) was used as indicator (in the heterogeneous phase). The complexing agent A^{2-} reacts with the cation M^{2+}, giving the stable and soluble complex MA. Meanwhile, the activity of the solution remains the same and is determined by the cosmic background and the ions $M_i{}^{*2+}$, arising in the dissociation of the precipitate ($M_i{}^*B$), according to its solubility product $L_{M_i{}^*B}$. After the complete disappearance of M^{2+}, the excess of added complexing agent reacts with $M_i{}^{*2+}$, dissolving the precipitate $M_i{}^*B$; the activity of the solution increases with increasing amount of complexing agent A^{2-} added after the equivalence point is reached. Fig. 1 shows the plot of the activity of the solution versus amount of complexing agent A^{2-}. The region *ab* of the curve corresponds to the reaction:

$$M^{2+} + A^{2-} \rightarrow MA \qquad (1)$$

and the region *bc* to the reaction:

$$M_i{}^*B + A^{2-} \rightarrow M_i{}^*A + B^{2-} \qquad (2)$$

In order that these reactions occur as above, the following conditions must be fulfilled: (1) the MA complex must be much more stable than the $M_i{}^*A$ complex, that is, $pK_{MA} > pK_{M_i{}^*A}$; (2) the solubility product $L_{M_i{}^*B}$ of the indicator precipitate and the stability constant $K_{M_i{}^*A}$ of the $M_i{}^*A$ complex must be related in such a manner as to shift reaction 2 to right; (3) M^{2+} must not react with the anion B^{2-} of the labelled precipitate, in order to avoid taking the radioactive cation $M_i{}^{*2+}$ out of the combination.

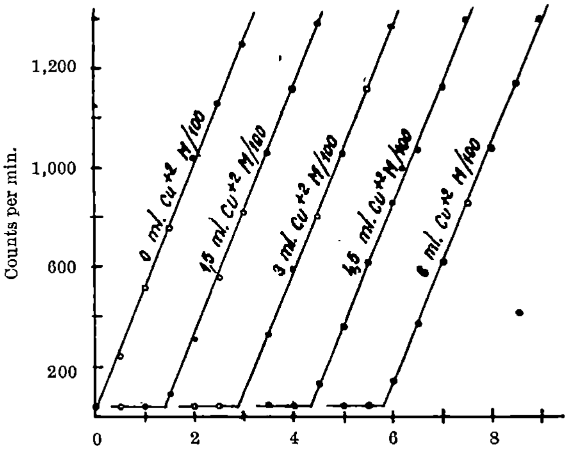


ml. complexant →
Fig. 1

The first system chosen for titrations was the following: complexon III was used as a complexing agent and radioactive silver as tracer (it gives a slightly stable complex with the complexing agent and may be used in the titration of many cations if condition 1 is fulfilled); silver has also a suitable half-life (270 days).

To get the radioactive tracer in the heterogeneous phase, radioactive silver was precipitated as Ag^*IO_3. The silver iodate is soluble, at convenient *p*H, in complexon III solutions according to condition 2. The titration of copper at a *p*H of approximately 9 will serve as an example. Fig. 2 shows the curves obtained when copper is titrated with complexon III using radioactive silver iodate as indicator in the heterogeneous phase. Curve 1 represents the titration of radioactive silver iodate with complexon without adding copper ions. Curves 2, 3 and 4 show the titration of different amounts of copper.

By this method a wide range of elements may be determined either by direct titration or by re-titration. Different complexing agents and radioactive indicators in the heterogeneous phase may be used, provided they fulfil the necessary conditions already mentioned.



ml. complexon III (*M*/100)
Fig. 2

In a paper to be submitted elsewhere the conditions in which a wide range of cations have been titrated in our laboratories will be described.

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The Free Amino-Acids of the Cerebrospinal Fluid

Current literature contains confusing reports about the number and nature of the free amino-acids normally present in human cerebrospinal fluid[1]. Thus, while some investigators have detected only three to eight amino-acids[2], others have found as many as eighteen[3]. In many instances, a particular amino-acid was not present regularly, but was only observed in a few cases. For this reason, reports which suggest that certain amino-acids occur exclusively in certain diseases can only be regarded as speculative. The aim of the present work has been to establish whether or not a regular pattern of amino-acids exists in normal and abnormal cerebrospinal fluid.

Separation of the amino-acids of a number of samples of cerebrospinal fluid by high-voltage paper electrophoresis, using buffer solutions of different pH, led to the identification of between six and eight amino-acids in each sample. Two-dimensional paper chromatography gave better results, but with this method some amino-acids present only in trace amounts were sometimes insufficiently separated for clear identification. High-voltage paper electrophoresis was therefore combined with paper chromatography and the following standard procedure adopted: 5–10 ml. cerebrospinal fluid was deproteinized with acetone and then desalted electrolytically in a modified Astrup desalting apparatus provided with an outer glass vessel containing an ice/salt cooling mixture. Under these conditions, adequate desalting for the high-voltage paper electrophoresis and chromatographic separation could be obtained in 5–10 min. without destruction of the amino-acids. The desalted solution was then evaporated to dryness *in vacuo* and the residue dissolved in distilled water (1/100 volume of original cerebrospinal fluid). 5–10 μl. of this solution was applied to a Schleicher and Schüll 2043*a* paper (60 cm. × 28 cm.), and high-voltage paper electrophoresis was conducted for 75 min. at 80–100 V./cm., in a fumaric - acetic acid buffer, $p\text{H} = 1{\cdot}9$, using a Werner and Westphal chamber[4]. The paper was then dried and run as an ascending chromatogram for 16 hr. with n-butanol/acetic acid/water (4 : 1 : 5) as solvent. It was developed with the ninhydrin reagent of Levy and Chung[5]. This technique enabled a clear separation and identification of most of the amino-acids in cerebrospinal fluid to be made. Identification of cysteine–cystine, methionine, phenylalanine, and proline was achieved by running one-dimensional chromatograms (using 30 μl. of solution = 3 ml. cerebrospinal fluid) which were then developed with specific reagents for these amino-acids.

A series of twenty cases was investigated using this method, and the following twenty-five substances were regularly found in the cerebrospinal fluid: alanine, α-amino-n-butyric acid, γ-amino-n-butyric acid, arginine, aspartic acid, cysteine–cystine, glutamine, glutamic acid, glycine, histidine, leucine-*iso*leucine, lysine, methionine, ornithine, phenylalanine, proline, serine, taurine, threonine, tryptophan, tyrosine, valine and three unknown substances, two of them probably biogenic amines. Occasionally, two other substances were also found, but these disappeared after hydrolysis; their electrophoretic and chromatographic characteristics suggested that they may be peptides.

The clinical diagnoses of the cases examined included cerebral atrophy of varying etiology, postencephalitic parkinsonism, cerebrospinal syphilis, diabetes insipidus, idiopathic and symptomatic epilepsy, cerebrovascular diseases, other neurological and non-neurological diseases; some normal individuals were also included. There was no correlation between the electroencephalogram, air-encephalogram, usual routine laboratory tests of cerebrospinal fluids and blood and the spectra of the free amino-acids in the cerebrospinal fluid.

From these results it is concluded that the qualitative analysis of the free amino-acids in the cerebrospinal fluid is of no diagnostic value. The amino-acids are basic constituents of both normal and pathological cells, and it is therefore unlikely that diseases which affect only a small percentage of the total number of nerve cells will alter the spectrum of free amino-acids in the cerebrospinal fluid over and above the large quantitative variations reported in the literature.

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Oxidation of Ethyl Alcohol to Acetic Acid by Proliferating Yeasts

In certain typical Spanish wines (Moriles, Montilla, Jerez, etc.), a film is formed on the surface after fermentation.

From a red wine of Galicia (Spain) I have isolated a strain of *Saccharomyces* that is able to form a film ('flor') on red wine (Fig. 1). Inoculated into grape must with a 23 per cent sugar content, this culture produces a vigorous alcoholic fermentation, typical of *Saccharomyces*, and after fermentation forms a film.

In studying the characteristics of this strain, I found that in the yeast nitrogen base for the carbon-assimilation tests of Wickerham, with 3 per cent of ethyl alcohol a pellicle is formed after 8 days at 25° C., and acid is produced; after 32 days at 25° C. the pH was 2·6 and finally 7·5 ml. $0{\cdot}1\,N$ sodium hydroxide were needed to neutralize 10 ml. of medium. The acid was exclusively acetic acid.

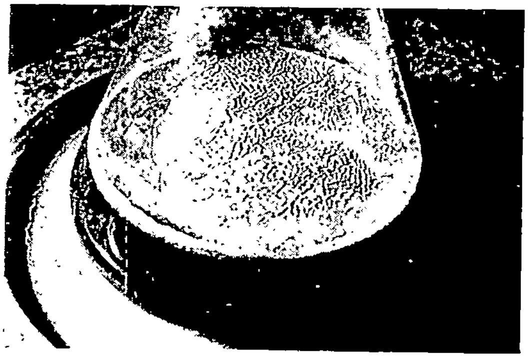

Fig. 1. *Saccharomyces aceti* strain *VT* 12–1, film on red wine after 25 days at room temperature

The same basal medium with 1 per cent of methanol showed, after 24 days, a slight growth, but it remained neutral and only a thin incomplete pellicle was formed. The cells of this pellicle were almost exclusively asci with one, two, three and four smooth, round ascospores (Fig. 2). *iso*Propanol is also oxidatively assimilated, with the production of acetone.

The culture can ferment glucose only; it can assimilate galactose, sucrose, maltose and lactose, but the assimilation is weak and in every case a thin pellicle is formed in which there are many asci. In malt extract broth, no pellicle is formed in three days at 25° C.

This organism is considered to be a new species in the genus *Saccharomyces*. The name *Saccharomyces aceti* is suggested. I have isolated two other strains of this species.

From a white wine of Montánchez (Cáceres, Spain) I have isolated another *Saccharomyces* strain, which also forms a film on white wine and on grape must after alcoholic fermentation. This strain shows a great resemblance to *Saccharomyces aceti* in its oxidizing properties, but it ferments glucose, saccharose and raffinose 1/3. I have isolated two other strains with the same properties, except for their sugar assimilation: the first of these three assimilated galactose and lactose weakly, the second assimilated maltose weakly, and the third did not assimilate galactose, maltose or lactose. I did not consider these differences important enough to differentiate these strains from the other one. These organisms are considered to be a new species in the genus *Saccharomyces*. The name *Saccharomyces oxidans* is suggested.

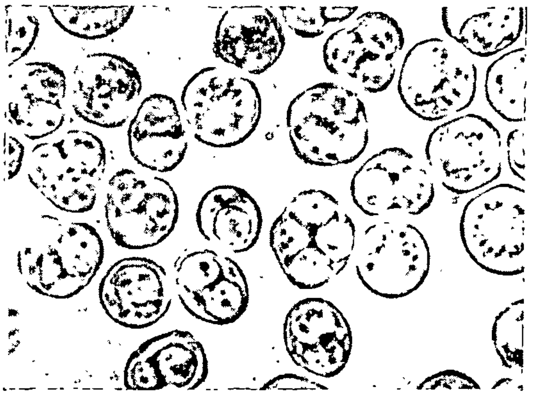

Fig. 2. *Saccharomyces aceti* strain *VT* 19–1. Asci with one, two, three and four spores. From the yeast nitrogen base of Wickerham with 1 per cent methanol, after 24 days at 25° C. Unstained. (× 1,750)

Cultures of *Saccharomyces aceti* and of *S. oxidans* have been deposited in the Yeast Collection of the Central Bureau voor Schimmelcultures in Delft.

A detailed account of this work, which was supported by a grant of the March Foundation, will be published elsewhere.

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Investigaciones Agronómicas,
Madrid. July 18.

Analeptic Action of Anibine

Anibine, the alkaloid from the wood of the South American rosewood trees (*Aniba Duckei* Kostermans and *Aniba rosaeodora* Ducke), has been shown to be 4-methoxy-6-(3′-pyridyl)-α-pyrone[1].

Investigating the pharmacological properties of this substance, we found its action to be similar to that of nikethamide, with which it also shares certain structural features. In the present communication we wish to report on the analeptic action of anibine and compare its toxicity with that of nikethamide.

Solutions of both substances of equal concentration and acidity were used in the tests. Nikethamide is miscible with water. The solubility of anibine or even of its hydrochloride in water is small at room temperature. Solutions of 2 per cent anibine adjusted to *p*H 3·5 with hydrochloric acid, prepared by heating, were stable for some time at 37°. Distilled water, physiological salt solution or isotonic glucose solution were used indifferently as diluents without affecting the results of the tests.

Anibine and nikethamide produced the same toxic symptoms in albino mice of 20 gm. weight when 1 ml. of the 2 per cent solutions (20 mgm.) was injected. Intravenous injections resulted in immediate clonic convulsions, congestion and nasal hæmorrhage followed by death. These symptoms were somewhat delayed if the injections were applied intraperitoneally. Intravenous injections of 0·5 ml. (10 mgm.) produced the same symptoms, even if at a slower rate, death following after 20–25 min. Intraperitoneal injections of 0·5 ml. of the 2 per cent solutions showed the difference in toxicity of the two substances. Animals injected with the solution of nikethamide suffered prolonged convulsions without lethal result during 1 hr.; animals injected with the solution of anibine did not show any disturbance.

Tests of analeptic action were carried out on male rabbits, weighing approximately 2 kgm., using solu-

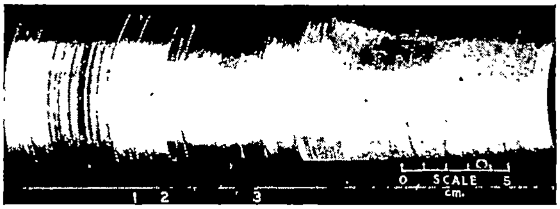

Fig. 1. Respiration record (pressure variation at the trachea) of a male rabbit, weighing 1·8 kgm., which remained without anæsthesia during the test (1 cm. on the abscissa = 1 min.). (1) Respiration-rate at the start, 100 per min. (2) Jugular injection of 12 mgm. of morphine hydrochloride: the respiration-rate fell to 75 per min. and the amplitude of breathing diminished. (3) Jugular injection of 20 mgm. of anibine in 1 ml. of isotonic glucose solution at 37°: the rate rose to 120 per min. and the amplitude increased

tions of different concentrations and recording graphically the effect upon breathing and arterial pressure. Intravenous injections of 0·5 ml. of 0·1 and 0·2 per cent solutions of anibine reduced slightly the arterial pressure. Higher doses (1 ml. of 2 per cent solution of anibine) produced a marked analeptic effect on animals the respiratory centres of which had been previously depressed by morphine (Fig. 1). Blank tests in which only the diluents, at the same pH, were injected failed to affect respiration.

One of us (O. R. G.) is indebted to the Conselho Nacional de Pesquisas, Brazil, for financial aid.

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Indole-3-aldehyde from Tissues

Salhanick and Berliner[1] studied a feminizing adrenal tumour from a man of 22. It weighed 920 gm., of which 523 gm. were used for chemical extraction. The frozen tissue was homogenized and extracted with acetone, leaving a 'protein' residue. The aqueous acetone was extracted with chloroform and the resulting lipid was partitioned between hexane and 75 per cent methanol. The latter was reduced to small bulk and extracted with chloroform to yield 0·67 gm. of yellow oil. The protein residue was digested with alkali (1 l. 5 per cent sodium hydroxide) for two days and extracted first with ether at pH 10 and then at pH 3 after acidification. After partitioning the extract, 0·26 gm. of oil was obtained. Chromatography on silica gel yielded progesterone, equilenin and two unidentified materials designated *AAE-I-BI* (44 μgm.) and *AAE-I-AI* (23 μgm.) from the acetone extract. From the protein hydrolysate extract the same materials were obtained in somewhat larger amounts (*AAE-I-AI*, 109 μgm.) together with three further unidentified fractions.

Substance *AAE-I-AI* showed (in methanol) absorption peaks at 242, 260 and 295 mμ and in concentrated sulphuric acid peaks at 240, 265 and 330 mμ. The published absorption curves show well-marked patterns of maxima and minima. The preparation exhibited a positive Millon test, regarded as indicative of a 3 : 5-unsubstituted hydroxyphenyl group ; it also gave a positive Zimmermann reaction for 17-ketosteroid. The total amount of material (132 μgm.) was very small, and there was no evidence as to purity. It was uncertain whether the chemical tests and the spectrophotometric characteristics were due to a single compound.

There can now, however, be little doubt that the spectroscopically recognizable constituent of *AAE-I-AI* was indole-3-aldehyde (Table 1) or a chromophorically identical substance.

The most surprising feature of the properties of the aldehyde is the change in absorption spectra in the presence of alkali.

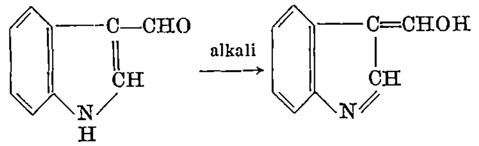
The indole nucleus shows an intense absorption band near 220–225 mμ and a region of weaker selective absorption around 270–280 mμ (order 10,000) with some fine structure. This applies to indole, 2-methyl-, 3-methyl- and 7-methyl-indole as well as to indole-3-acetic acid and tryptophan. Addition of sodium ethoxide to ethanolic solutions effects no marked change.

Table 1. Properties of Indole-3-aldehyde (Formylindole)

Solvent*	$\lambda_{max.}$ (mμ)	$\epsilon_{max.}$	$\lambda_{min.}$ (mμ)	$\epsilon_{min.}$
Ethanol	242	13,700	227	4,700
	260	11,700	252	11,000
	296	13,440	272	7,200
Ethanolic sodium ethoxide (0·1 *M*)	266	19,900	237	2,500
	326	20,400	293	5,850
Concentrated sulphuric acid	235	28,800	220	17,900
	266	54,200	250	28,700
	329	46,700	285	10,100

* See also G. F. Smith (ref. 2) for aqueous and aqueous alkaline solutions.

The new effect with indole-3-aldehyde has been attributed to the change :



In fact, we have found that there is an equilibrium which varies with the pH.

Indole-3-aldehyde has also been shown[3] to be one of the photochemical products of the irradiation of indole-3-acetic acid with light of wave-length 280 mμ.

In the course of an extended study of tissue unsaponifiable fractions we have noted a material (fraction *SF*) showing $\lambda_{max.}$ 235 and 282 mμ (in *cyclo*hexane) and $\lambda_{max.}$ 242 and 295 mμ (inflexion 260 mμ in ethanol). Among the best sources of this material were pancreas and spleen from several species. By chromatography on alumina the E(1 per cent, 1 cm., 282 mμ) value was raised to 50 and at that stage a small quantity was subjected to molecular distillation and yielded a few mgm. of white crystals. The absorption curves for this preparation in ethanol and in sulphuric acid reproduced those of *AAE-I-AI* but the chemical constitution remained unknown. The crystals gave a negative Millon reaction and a positive Tollens reaction. Small amounts of molecular distillates were kindly examined for us in the mass spectrograph at the Thornton Research Laboratories of Shell, Ltd. Mr. A. Quayle and his colleagues (to whom we are much indebted) found in the purer preparation evidence that the largest particles were of mass number (molecular weight) 144 and 145 and with nitrogen present it was suggested that an indole derivative was possible. Examination of authentic indole-3-aldehyde soon confirmed the nature of the selectively absorbing substance. It is perhaps too early to discuss in detail the significance of the detection of indole-3-aldehyde in the adrenal tumour, in normal pancreas and spleen and in the photoproducts of indole-3-acetic acid. The idea that it is a straightforward artefact derived from the tryptophan of proteins is not consistent with the evidence.

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Effect of Vitamin B Complex on the Teratogenic Activity of Hypervitaminosis A

Some years ago, attention was directed by Cohlan[1] to the teratogenic effects of large doses of vitamin A administered to laboratory animals during pregnancy. His observations have since been fully confirmed by a number of workers.

Recently, it has been shown that the teratogenic activity of hypervitaminosis A can be modified by the concurrent administration of other substances. In particular, it has been observed that cortisone and 4-methyl-2-thiouracil augment or potentiate the teratogenic action, whereas insulin tends to diminish it[2].

Among the commonest malformations of the young induced by maternal hypervitaminosis A are cleft palate and deformities of the brain and skull such as exencephaly and hydrocephaly. Maternal deficiencies in vitamins of the B complex have also been shown experimentally to result in the production of similar fœtal anomalies[3].

Suggestions have been made from time to time that the effect of hypervitaminosis A in animals is to produce a 'displacement deficiency' in the B group of vitamins[4]. Accordingly, it was decided to investigate the possibility that the concurrent administration of the B vitamins in large doses might mitigate the teratogenic effects of hypervitaminosis A. In the experiments reported here a 'blunderbuss' injection of B vitamins was employed as a preliminary to an examination of the effects of individual vitamins of the B group.

Female rats of the Wistar strain were used as in the experiments reported previously. Vitamin D (2,000 i.u.) and 50 mgm. vitamin E were given by mouth at the beginning of the experiment. After mating with normal male rats, pregnancy was determined by the presence of spermatozoa in the vagina. One group of pregnant female rats received 40,000 i.u. vitamin A acetate daily by gastric intubation from the eighth to thirteenth days of pregnancy. A second group received 40,000 i.u. vitamin A daily and, in addition, 0·5 ml. vitamin B complex by subcutaneous injection from the eighth to thirteenth days. The B injection contained aneurine hydrochloride 25 mgm., nicotinamide 16 mgm., riboflavin 0·4 mgm., pyridoxine hydrochloride 5 mgm. in benzyl alcohol, 14 mgm., as a vehicle.

The rats were killed on the twentieth day of pregnancy and the young removed for examination. Only gross deformities involving the brain or palate were considered.

In the group of rats which received vitamin A alone, 9 young out of 121 showed deformities of the brain, an incidence of 7·4 per cent. No young with deformities of the brain were encountered among the young from the groups which received both vitamin A and vitamin B complex. The results of the experiment in relation to malformations of the palate are shown in Table 1. It will be noted that when vitamin A alone was given, 31·4 per cent of the young showed clefts of the palate, whereas when vitamins of the B group were given in addition only one of the young had a cleft palate, an incidence of 1·5 per cent.

It seems reasonable from these experiments to reach the tentative conclusion that the failure of vitamin A to produce a comparable incidence of malformations in the two groups was due to the presence, in the second group of animals, of a large amount of vitamins of the B group. Further experiments are in progress with the view of determining whether the protective effect requires the presence of a number of B vitamins or is mediated by a single member of the group.

Table 1

Treatment	No. of rats	Total No. of young	No. of young with cleft palate	Percentage of young with cleft palate
Vitamin A	16	121	38	31·4
Vitamin A Vitamin B	9	65	1	1·5

The hypothesis that it is the relative balance between the amounts of different vitamins which is critical for normal development receives some additional support from these experiments. Furthermore, the results are not discordant with the view that an excess of vitamin A may produce a degree of vitamin B deficiency which can be compensated by the concurrent administration of this vitamin.

This work was supported by a grant from the Nuffield Foundation which is gratefully acknowledged.

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Ribonuclease and Deoxyribonuclease Activities during Normal and Neoplastic Growth

A relationship has been repeatedly demonstrated between the rate of growth of a tissue and its ribonuclease (RNase) and deoxyribonuclease (DNase) activities[1-4].

These findings stimulated the present investigation. The nucleic acid content and nuclease activities of a number of human and animal malignant tumours have been determined. The determinations were carried out as described earlier[1 2]. Except in the case of the Ehrlich ascites tumour the tissues of origin have also been examined.

The results are summarized in Table 1. As in previous papers[1-3] enzyme activities are expressed relative to deoxyribonucleic acid–phosphorus content. In some tumours the ribonuclease activity was equal to that in the tissue of origin; in others it was lower. Only in pancreatic carcinoma was there an increase. Ledoux *et al.*[5] have recently reported that in human cervical cancer the ratio of acid ribonuclease activity to ribonucleic acid content is lower than in the normal tissue of origin. Accordingly, the corresponding ratios have been calculated for the tissues examined in the present experiments (Table 1). Two of the tumours gave results which support Ledoux's concept: the Ehrlich ascites carcinoma, which contained no measurable ribonuclease; and one case of stomach carcinoma in which the ribonuclease/ribonucleic acid ratio, although high, was significantly lower than the ratio given by the gastric mucosa of the same patient.

Table 1. Nucleic Acid Content and Nuclease Activities in Normal and Neoplastic Tissues

Tissue	μgm. RNAP/mgm. dry weight	μgm. DNAP/mgm. dry weight	RNAP/DNAP	RNase/μgm. DNAP*	RNase/μgm. RNAP*	DNase/μgm. DNAP†
Human :						
Gastric mucosa	1·91	1·21	1·58	24·1	15·3	1·98
Cancer of the stomach	3·55	2·14	1·65	26·8	16·3	2·39
Gastric mucosa	1·42	0·76	1·88	97·0	51·7	2·71
Cancer of the stomach	1·94	1·36	1·43	49·2	34·4	2·68
Liver	10·65	2·84	3·76	5·5	1·5	8·35
Cancer of the liver	1·41	1·14	1·24	5·9	4·8	2·32
Pancreas	12·31	1·03	11·91	2·3	0·19	3·10
Cancer of the pancreas	3·26	0·42	7·72	5·5	0·71	4·02
Animal :						
Mammary gland, pregnant rat	0·92	0·29	3·17	0·39	0·13	5·6
DMBA tumour‡	4·89	3·65	1·34	0·19	0·15	6·0
Ehrlich carcinoma, ascitic form	9·63	3·18	3·03	No measurable activity	—	0·7

* Ribonuclease activities determined by incubating tissue breis with ribonucleic acid at pH 7·70, adding trichloracetic acid–lanthanum acetate, centrifuging and reading the optical density in the supernatant against the appropriate blank. The activities are expressed as optical density increase/hr./μgm. tissue deoxyribonucleic acid–phosphorus or ribonucleic acid–phosphorus (DNAP or RNAP).

† Deoxyribonuclease activities determined by incubating tissue breis with deoxyribonucleic acid at pH 5·25 and following the procedure above. The increase in deoxypentose in the supernatant was determined colorimetrically and from this the amount of deoxyribonucleic acid–phosphorus was calculated. The deoxyribonuclease activities are expressed as deoxyribonucleic acid–phosphorus liberated per hr./μgm. tissue deoxyribonucleic acid–phosphorus.

‡ Dimethylbenzanthracene tumour. These have been studied by Scholler *et al.* (ref. 8). They were obtained through the courtesy of Dr. Jean Scholler.

In the other tumours the ratio was equal to or greater than that of the tissue of origin. It therefore appears that a diminished alkaline ribonuclease/ribonucleic acid ratio is not characteristic of all tumours.

In general, the deoxyribonuclease activities of the neoplastic tissues studied did not differ greatly from those of the tissue of origin. The only exception was a hepatic carcinoma which had a deoxyribonuclease activity only 25–30 per cent that of liver.

Although the growth-rates of neoplastic tissues differ within wide limits, they usually grow faster than their tissues of origin. The incorporation of isotopes into various cellular constituents, in particular into the nucleic acids, also occurs at higher rates in tumours than in their tissues of origin[6]. In this respect there is a similarity between rapidly growing non-malignant and neoplastic tissues. The synthetic activities as reflected by the rate of isotope incorporation are apparently stimulated in both types of growth. The ribonuclease and deoxyribonuclease activities, on the other hand, show completely different patterns in normal and neoplastic growth. Whereas the normal tissue response to a growth stimulus involves a sharp increase in the activities of these enzymes, neoplastic tissues do not seem to respond in this way.

There has been some speculation on the role of the nucleases in the synthesis or degradation of nucleic acids *in vivo*. There is a positive correlation between the activities of these enzymes and the rate of isotope incorporation into the nucleic acids during the non-malignant growth[4] in regenerating liver. This suggests a synthetic activity. The lack of correlation, however, which is found during neoplastic growth argues against this interpretation. It is more likely that they have a degradative or regulatory function. The parallelism in normal growth between nuclease activities and the rate of isotope incorporation into the nucleic acids contrasts sharply with the absence of such a relationship during neoplastic growth. During normal growth the synthetic activities[7] seem counterbalanced by the ribonuclease and deoxyribonuclease activities, whereas in neoplastic growth there appears to be an imbalance between these systems. The events during carcinogenesis leading to this state are now the subject of investigation in this laboratory and a report will shortly be published.

We wish to thank Dr. Alexander Brunschwig for kindly supplying us with operative specimens, and Dr. George Bosworth Brown for his encouragement and interest. We wish to acknowledge a grant from the American Cancer Society and the Swedish Cancer Society to Dr. Sam Brody. This investigation was supported in part by funds from the American Cancer Society, National Cancer Institute, National Institutes of Health, Public Health Service (Grant *CY*–3190), and from the Atomic Energy Commission (Contract No. *AT*(30–1)–910).

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Physical Reactivity of Liver and Brain Cortex Mitochondria

In recent investigations[1] we found that rat brain cortex mitochondria, isolated in 0·25 M sucrose by method II of Brody and Bain[2], had, in the same experimental conditions, certain physical properties different from those of rat liver mitochondria isolated by the method of Myers and Slater[3]. The incorporation of 0·01 M ethylenediaminetetraacetate in the 0·25 M sucrose, used by Slater[4] in the preparation and stabilization of heart sarcosomes, has yielded some results concerning the apparent stability of brain granules at 25° C. The ethylenediaminetetraacetate used was the disodium salt, brought to pH 7·5 with potassium hydroxide, and the solution was made up with de-ionized water. Experiments were performed with mitochondria isolated from the liver and the brain cortex of normal white rats (Wistar strain), three months old. The tissues were

Table 1. Rate of Variation in Optical Density of Suspensions of Liver and Brain Cortex Mitochondria obtained at 25° C., in 1-cm. Cells at 550 mμ. The Zero-Time Value was obtained by Extrapolation and was approximately 0·3. Each Percentage Number represents the Mean Value of Four Experiments

Mitochondria isolated in 0·25 M sucrose							
Condition	Other additions	Percentage variation of optical density					
		Liver			Brain cortex		
		2 min.	6 min.	10 min.	2 min.	6 min.	10 min.
0·05 M sucrose 0·01 M *tris* pH 7·4	None	+ 6	0	− 21	− 6	− 10	− 9
	10^{-3} M $CaCl_2$*	+ 12	+ 12	+ 3	+ 1	+ 2	+ 3
	10^{-3} M $MgCl_2$	+ 4	+ 7	+ 7	+ 1	− 1	− 1
	5×10^{-3} M $MgCl_2$				+ 5	+ 8	+ 10
	10^{-3} M $Na_2HPO_4.2H_2O$	− 28	− 32	− 33	− 6	− 9	− 9
	10^{-3} M ATP	+ 5	+ 9	+ 10	− 6	− 9	− 11
Mitochondria isolated in 0·25 M sucrose + 0·01 M ethylenediaminetetraacetate							
0·05 M sucrose 0·01 M *tris* pH 7·4	None	− 3	− 4	− 4	− 11	− 18	− 20
	10^{-3} M $CaCl_2$	+ 6	− 4	− 16	+ 2	+ 2	0
	10^{-3} M $MgCl_2$	− 1	0	+ 2	− 2	− 3	− 3
	5×10^{-3} M $NaH_2PO_4.2H_2O$	+ 4	+ 6	+ 7	− 5	− 8	− 9
	10^{-2} M $NaH_2PO_4.2H_2O$				− 2	− 2	− 3
	10^{-3} M ATP				− 14	− 19	− 22
	10^{-5} M $CoCl_2$	− 3	− 2	0	− 12	− 17	− 20
	10^{-5} M $HgCl_2$	0	+ 2	+ 4	− 9	− 13	− 15
	10^{-5} M $Ag(NO_3)_2$				− 9	− 12	− 14

* The percentage number was − 27 at 16 min.

rapidly homogenized in a Potter–Elvehjem homogenizer fitted with a 'Teflon' pestle, with ten volumes of the sucrose–ethylenediaminetetraacetate medium. Nuclei, erythrocytes, intact cells and debris were sedimented by centrifugation at 700*g* for 10 min., and the mitochondria then separated by centrifugation of the supernatant fluid at 8,500*g* for 10 min. (rate controlled by an electronic stroboscope, Philips *PR* 9103). The mitochondria were washed by resuspension and resedimentation in the same conditions. The final pellets were suspended in the sucrose–ethylenediaminetetraacetate medium, so that the mitochondria from 0·80 gm. of fresh liver or from 0·90 gm. of fresh brain cortex were suspended in 1·0 ml. All operations were carried out at 0° C. The purity of isolated fractions was controlled morphologically with phase microscopy and chemically by the colorimetric test of Potter, Recknagel and Hurlbert[5] (reduction of janus green *B* to yield diethylsafranine at 37° C.). The mitochondria were used immediately following their isolation. Mitochondrial volume changes were studied at 25° C. by following the optical density of suspensions at 550 mμ, in 1-cm. cells, with a Meunier photometer (Jobin and Yvon, Arcueil), as described by Cleland[6]. The basic test system (volume 7 ml.) contained mitochondria (about 0·03 ml. of the stock suspension, giving an initial optical density of approximately 0·300) suspended in 0·05 M sucrose and 0·01 M *tris* (hydroxymethyl) aminomethane, *p*H 7·4; the solution was made up in de-ionized water. The first reading was taken 30 sec. after the addition of the mitochondria and subsequent readings at 2-min. intervals for 10 min.; the zero-time value was obtained by extrapolation.

Table 1 and Fig. 1 show that the addition of 0·01 M ethylenediaminetetraacetate to the isotonic sucrose medium during the preparation of mitochondria provided liver granules which were very stable when tested in the hypotonic sucrose medium, in complete agreement with earlier results[7]; the brain granules, however, swelled rapidly. On the other hand, the swelling of brain mitochondria was largely prevented by calcium ions; in contrast, these ions at the same concentration (10^{-3} M) produced rapid swelling in liver mitochondria. Magnesium ions also prevented the swelling of brain granules, but had no effect on the stability of liver granules.

As pointed out by Slater[4], it might be expected that the addition of the chelating agent ethylenediaminetetraacetate to the isolation medium would remove essential metals from the mitochondria, as well as prevent the binding of calcium ions by the granules. Christie, Judah and Rees[8] concluded that cobalt activates and stabilizes respiration in brain mitochondria treated with certain chelating agents (but not ethylenediaminetetraacetate). Table 1

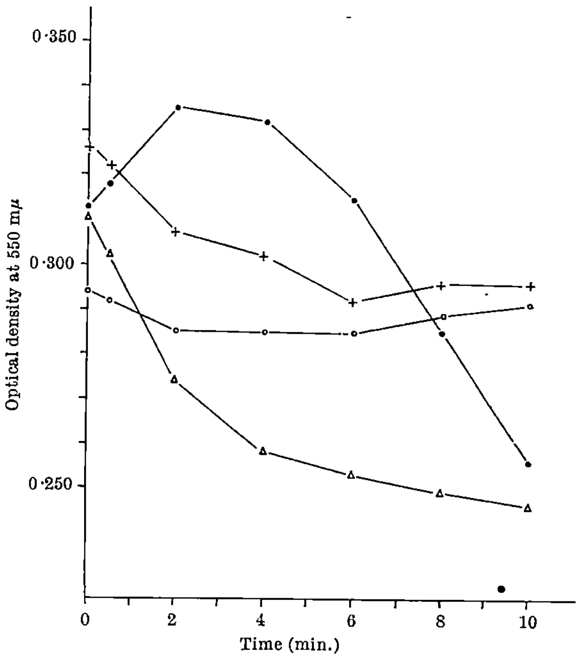

Fig. 1. Influence of the method of isolation on the degree of swelling of rat liver and brain cortex mitochondria. The test medium contained 0·05 M sucrose and 0·01 M *tris* buffer *p*H 7·4, at 25° C. Liver (●—●) and brain cortex (+—+) mitochondria isolated in 0·25 M sucrose. Liver (○—○) and brain cortex (△—△) mitochondria isolated in 0·25 M sucrose + 0·01 M ethylenediaminetetraacetate

shows that cobalt ions (10^{-5} M) did not affect the swelling of brain granules. On the other hand, Slater[4] supposed that ethylenediaminetetraacetate would also activate sensitive —SH enzymes by removing contaminating heavy metals. In Table 1 we see that mercuric and argentic (Ag^{++}) ions had no effect on the swelling of brain mitochondria; mercuric ions had a slight preventive effect on liver mitochondria.

Hunter and Ford[7] considered the protective effect of ethylenediaminetetraacetate against pre-incubation of liver mitochondria with phosphate to be completely unexpected. Our results (Table 1) confirm earlier ones but in contrast phosphate had a slight preventive action on the swelling of brain mitochondria. Numerous authors[4,7,9] established that adenosine triphosphate had a strong preventive effect on the swelling of liver mitochondria, heart sarcosomes and cytoplasmic granules of diverse tissues. In this paper we confirm our earlier results[1]: adenosine triphosphate, at a concentration of 10^{-3} M, had no preventive effect on the swelling of brain cortex mitochondria isolated in the sucrose–ethylenediaminetetraacetate medium.

Berger[10] concluded that the different sensitivity of the mitochondria of liver and brain tissues towards chlorpromazine is determined rather by the structural differences than by some intrinsic differences in metabolic pattern: brain mitochondria has a greater adsorption capacity than liver mitochondria. This capacity was confirmed recently by Kunz[11], who has shown that, in contrast to rat liver mitochondria, brain granules do not require the addition of magnesium ions for the oxidative decarboxylation of pyruvate. Our preliminary results support the view that the so-called membrane of the brain mitochondria possesses a specific structure which confers a high physical stability on these granules.

This work will be continued and will be published in full elsewhere.

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Identification of Meprobamate by Adsorption Chromatography on Chromatoplates

Methods have recently been proposed (refs. 1 and 2 and Walkenstein, S., Knebel, C., MacMullen, J., and Seifter, J., private communication) for the identification and quantitative determination of 2-methyl-2-*n*-propyl-1,3-propanediol dicarbamate (meprobamate) in blood and urine. These methods are sensitive and practical but appear to be insufficiently specific for use in analytical toxicology.

Paper chromatography was employed by Riebeling[3] for the detection of meprobamate combined with glycuronic acid in urine, but only the glycuronic acid is in fact detected by this method. Applications of paper chromatography to the separation and identification of meprobamate are very difficult because the compound is insoluble in water and because there are no methods for detecting the spots.

We have successfully employed a method for identifying meprobamate, based on adsorption chromatography on chromatoplates.

Chromatoplates were prepared using Demole's[4] modification of Reitsema's method[5]. 54 ml. of distilled water is added to a mixture of 28·5 gm. of pure silicic acid and 1·5 gm. of rice starch. The suspension is heated over a flame almost to boiling point to obtain a thick paste which is then diluted with 20–30 ml. of water and again heated to the same temperature for some minutes. After cooling, 10 ml. of the suspension is poured into the centre of a glass plate 17 cm. × 11 cm. × 0·2 cm. The liquid is quickly distributed on the surface with a spatula, and the layer is made homogeneous by rapid transverse movements of the plate.

Chromatoplates are left to dry for a few hours at room temperature and are then activated by heating in an oven for 30 min. at 100–105° C. The chromatoplates so prepared are stored in desiccators with anhydrous calcium chloride.

Meprobamate is isolated from urine by adding 0·2 ml. of N sodium hydroxide and 10 ml. of ether to 5 ml. of urine in a glass-stoppered centrifuge tube.

After shaking, the tube is centrifuged, the ether is decanted, and 60 mgm. of charcoal is added. This mixture is again shaken, filtered and evaporated to dryness under a stream of air. The dry residue is dissolved in 0·1 ml. of ethyl alcohol and known amounts of the alcoholic solution are quickly spotted on the starting line of the chromatoplate under a stream of hot air. The spotting of the plates inside the desiccator, as suggested by Demole[4], was found to be unnecessary for routine work.

Ascending development is carried out in a glass jar with cyclohexane and absolute ethyl alcohol (85 : 15) as solvent. After development for about 2 hr., when the solvent is 10–11 cm. from the starting line, the chromatoplate is removed, dried at room temperature and sprayed lightly with concen-

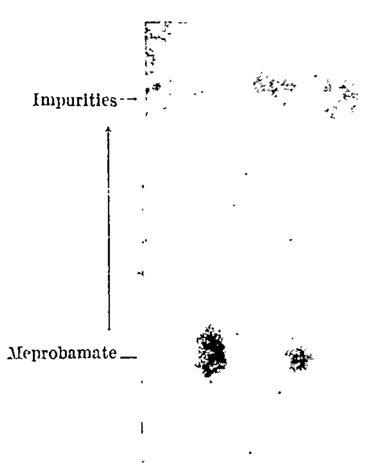

Fig. 1

trated sulphuric acid. A suitable sprayer bottle is described by Kirchner *et al.*[6]. The plate is then heated in an oven at 110–115° C. for 2–3 min., sprayed lightly with distilled water and reheated as before for some minutes, until yellow spots of meprobamate appear. Overheating should be avoided to prevent darkening of the chromatoplates. The spots, which disappear in about a day, have R_F 0·30. Exact R_F values are obtained only in the central zone of the chromatograms; at the periphery of the plates R_F values are higher, due to the border effect. Unidentified impurities migrate with the solvent front (Fig. 1) and become violet under the sulphuric acid treatment.

A quantitative determination can be easily made by cutting out the spot and transferring it to a test tube. 1 ml. of distilled water is added, and then after careful shaking, 1 ml. of a 0·2 per cent hydroquinone in concentrated sulphuric acid[3]. The test tube is then heated in a boiling water bath for 20 min., till a yellow colour is obtained; this has an absorption maximum at 420 mμ and can therefore be determined spectrophotometrically.

Further details will be published elsewhere.

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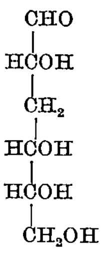
Synthesis of 3,6-Dideoxy-D-*ribo*-hexose (3,6-Dideoxy-D-glucose) and its Identification with Paratose

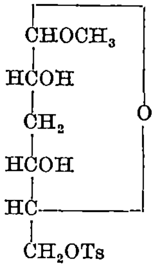
3,6-DIDEOXY-HEXOSES are a new class of natural sugars; five members of this group are known at present: abequose[1], tyvelose[1,2], paratose[3] and colitose[4] have been found in specific polysaccharides extracted from various species of *Salmonella*, and ascarylose is obtained by hydrolysis of three glycolipids (the ascarosides *A*, *B* and *C*) extracted from the egg membrane and the cuticle of *Parascaris equorum*[5]. We have shown that all these sugars are 3,6-dideoxy-hexoses[6,7].

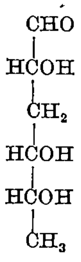
In a recent paper[8], we reported the synthesis of 3,6-dideoxy-D-*xylo*-hexose (3,6-dideoxy-D-galactose) and 3,6-dideoxy-D-*arabino*-hexose (3,6-dideoxy-D-mannose) and showed that the first is identical with abequose and the second with tyvelose, while colitose is the optical antipode of abequose and ascarylose is the optical antipode of tyvelose.

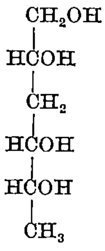
We now report the synthesis of 3,6-dideoxy-D-*ribo*-hexose (3,6-dideoxy-D-glucose) (III) and its identification with paratose.

3,6-Dideoxy-D-*ribo*-hexose (3,6-dideoxy-D-glucose) (III) was synthesized starting from 3-deoxy-D-*ribo*-hexose (3-deoxy-D-glucose) (I) kindly supplied by Drs. J. W. Pratt and N. K. Richtmyer[9]; the methylglucoside of this compound was tosylated, and after chromatography on magnesium silicate the methyl 3-deoxy-6-tosyl-D-*ribo*-hexoside (II) was obtained as a colourless syrup which was reduced by lithium aluminium hydride in a mixture of ether and benzene (1 : 1). After the usual treatment the methyl 3,6-dideoxy-D-*ribo*-hexoside was extracted with chloroform, the extract hydrolysed with 0·1 *N* hydrochloric acid in boiling water, and the free sugar then chromatographed on a column of Whatman cellulose powder. After elution of the sugar (II) with acetone/water (95 : 5) it was distilled at 0·05 mm. and obtained as a colourless syrup, $[\alpha]_D + 10 \pm 2°$; R_F 0·71 in butanol/pyridine/water (6 : 4 : 3); calculated for $C_6H_{12}O_4$: C, 48·64; H, 8·16 per cent; found: C, 48·68; H, 8·23 per cent.


I


II


III


IV

The corresponding hexitol (IV) was prepared by reduction with sodium borohydride in water and obtained as crystals after distillation at 0·05 mm. After recrystallization from acetone, 3,6-dideoxy-D-*ribo*-hexitol (IV) was obtained as colourless needles, melting at 67–68°; $[\alpha]_D$ −18 ± 2°; R_F 0·53 in butanol/pyridine/water (6 : 4 : 3); calculated for $C_6H_{14}O_4$: C, 47·98; H, 9·40 per cent; found: C, 47·93; H, 9·68 per cent.

Paratose, which has recently been isolated by Davies *et al.*[3] from a polysaccharide of *Salmonella paratyphi A*, is a syrup, $[\alpha]_D + 8 \pm 2°$, and the hexitol (paratitol) obtained by reduction with sodium borohydride melts at 66–68° and has $[\alpha]_D - 16 \pm 2°$. (Found: C, 47·61; H, 9·52 per cent.)

The mixed melting point of paratitol and 3,6-dideoxy-D-*ribo*-hexitol (3,6-dideoxy-D-sorbitol) (IV) gave no depression. R_F values and infra-red spectra of both paratose and the crystalline hexitol are identical with those of the respective synthetic compounds.

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Beta-globulin Polymorphism in Cattle, Sheep and Goats

Detection by paper electrophoresis. Using starch gel electrophoresis, six cattle[1], fourteen sheep[2], three goat (see later) and three human[3,4] β-globulin phenotypes have been recognized and indicated to be under the genetic control of three, five, two and three allelomorphs respectively. As one of us had noticed a variation in the number and position of the β-globulin zones in paper electrophoresis of animal sera, the two methods have been compared on sera from cattle, sheep and goats. Starch gel electrophoresis was carried out in phosphate buffer[1] *p*H 7·6, paper electrophoresis on a wide strip of horizontally suspended Whatman 3*MM* paper in barbiturate buffer *p*H 8·6, *I* 0·05. Typical examples of corresponding electropherograms of sheep and cattle sera are shown in Figs. 1 and 2. The electropherograms of goat sera shown in Fig. 3 are discussed below.

Table 1. OBSERVED AND EXPECTED DISTRIBUTION OF OFFSPRING PHENOTYPES FROM GOAT β-GLOBULIN MATINGS

Mating	Offspring β^{AA} Obs.	Exp.	β^{AB} Obs.	Exp.	β^{BB} Obs.	Exp.
$\beta^{AA} \times \beta^{AA}$	No matings					
$\beta^{AA} \times \beta^{AB}$	8	8·5	9	8·5	0	0
$\beta^{AA} \times \beta^{BB}$	0	0	9	9	0	0
$\beta^{AB} \times \beta^{AB}$	1	0·75	1	1·5	1	0·75
$\beta^{AB} \times \beta^{BB}$	0	0	4	5·5	7	5·5
$\beta^{BB} \times \beta^{BB}$	No matings					

It is evident that the different phenotypes in these animals can be distinguished by paper electrophoresis on the basis of β-globulin components of different mobilities. In the simple phenotype system observed in goats (see later), paper electrophoresis was in fact used successfully for independent typing of the sera. From an observation of Smithies[3], it seems likely that human phenotypes could be distinguished on paper also.

Consideration of the electropherograms of homozygous sera shows that each β-globulin zone on paper corresponds to a group of zones in starch-gel electrophoresis, the number of zones in the group depending on the species. In sheep and goats there is a faint zone followed by an intensely staining zone, whereas in cattle there is a faint zone followed by a moderately staining zone and two intensely staining zones, described in order of decreasing mobility in the gel.

Comparison of the electropherograms of homozygous and heterozygous sera shows that some of the zones into which the β-globulin components are resolved in starch gel are superimposed in some of the heterozygous sera, particularly in cattle. When this occurs, resolution by paper electrophoresis becomes incomplete and the β-globulins usually appear as a broad zone. This superimposition also makes it difficult to apply a system of nomenclature based on individual coding of the starch gel zones[5] without knowing more about the resolving mechanism and interrelations of the zones in starch gel[6].

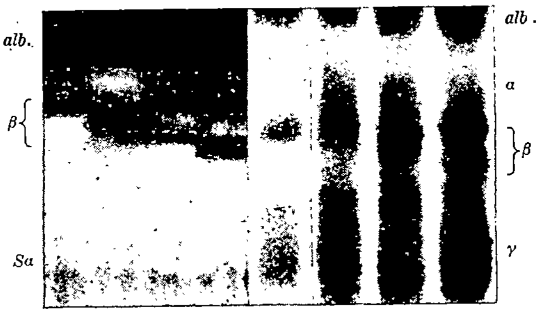

Fig. 1. Electropherograms of sheep sera showing β-globulins of sheep sera of four different phenotypes. Left, starch gel; right, paper electrophoresis. Key: α, β and γ = α-, β- and γ-globulins. *alb.*, albumin; *Sa*, slow alpha zone

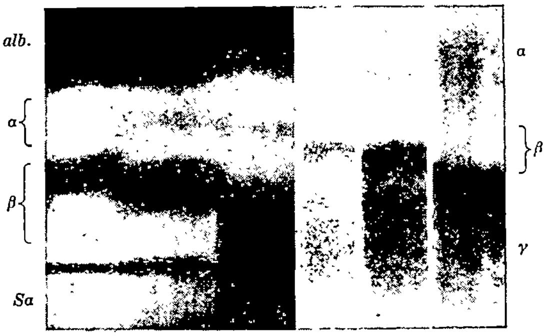

Fig. 2. Electropherograms showing β-globulins of three homozygous cattle sera. Left, starch gel; right, paper electrophoresis. Key: as Fig. 1

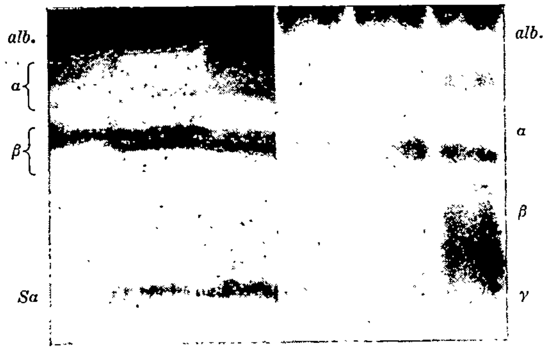

Fig. 3. Electropherograms of goat β-globulin phenotypes. Left, starch gel; right, paper electrophoresis. In each case the phenotypes are from left to right β^{AA}, β^{AB} and β^{BB}. Key: as Fig. 1

β-*Globulin polymorphism of goats.* Sera from about sixty goats of the British Saanan breed at the Rowett Research Institute have been examined by starch gel electrophoresis using phosphate buffer[1] and by paper electrophoresis. This revealed three phenotypes shown in the electropherograms of Fig. 3. (The two methods are compared above.)

Some animals were examined twice with intervals of up to a year and the phenotype found to be constant. It was also found that mixed sera of the two outermost phenotypes shown in Fig. 3 were indistinguishable from the third (centre) when run together in starch gel. This suggested that the β-globulins of goats are controlled by two allelomorphs β^A and β^B, giving rise to the genotypes β^A/β^A, β^A/β^B and β^B/β^B, and the three phenotypes β^{AA}, β^{AB} and β^{BB}. This hypothesis is supported by mating results shown in Table 1, where the observed and expected distribution of phenotypes of some forty offspring are compared.

This genetic mechanism is similar to that proposed for β-globulin polymorphism in cattle, sheep and man.

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Structure of Cardiolipin

Pangborn[1] considered that the glycerylglycerophosphate skeleton of cardiolipin contained three phosphoric acid and four glycerol residues (I), the six available hydroxyl groups in this structure being esterified with unsaturated fatty acids in the intact phospholipid.

$$\text{(I) } CH_2OH.CHOH.CH_2O.P : O(OH).CH_2O.CHOH.CH_2O.P : O(OH).CH_2O.CHOH.CH_2O.P : O(OH).CH_2O.CHOH.CH_2OH$$

Macfarlane and Gray[2] suggested a simpler structure for cardiolipin of two phosphoric acid, three glycerol and four fatty acid residues, with a free hydroxyl group on one of the glycerol residues. Evidence in favour of this structure has been obtained by oxidative degradation of the deacylated polyglycerophosphate.

Cardiolipin, prepared from ox heart by the method of Faure and Morelec-Coulon[3], was saponified in 1 per cent ethanolic potassium hydroxide at 20° for 4 hr. The phosphorus was recovered as the potassium salt, insoluble in ethanol, of the polyglycerophosphate (orthophosphate nil; phosphomonoester by enzymic assay nil). The ester was treated in aqueous solution with 50 per cent excess of sodium periodate at 20° for 30 min., and the formaldehyde produced was estimated colorimetrically with chromotropic acid; found, molar ratio formaldehyde : phosphorus, 1·03 : 1·0. The iodates were removed as the insoluble barium salts and the formaldehyde by repeated evaporation of the solution to dryness in a vacuum desiccator. The phosphorus was recovered as the soluble barium salt of a complex ester (orthophosphate and phosphomonoester, nil). The aldehyde content of the ester was estimated by oxidation with hypoiodite by the method of Macleod and Robison[4]; found, 0·87 mole aldehyde/mole phosphorus. The results indicate that the polyglycerophosphate skeleton of cardiolipin consists of three glycerol residues linked by two phosphoric acid residues (II); on oxidation of the terminal glycerol residues with periodate II would give 2 moles of formaldehyde and glyceroldi-(formylmethyl hydrogen phosphate) (III). The ester linkages are assigned arbitrarily to the α position.

$$CH_2OH.CHOH.CH_2O.P : O(OH).CH_2O.CHOH.CH_2O.P : O(OH)CH_2O.CHOH.CH_2OH \quad \text{(II)} \rightarrow$$
$$CHO.CH_2O.P : O(OH).CH_2O.CHOH.CH_2O.P : O(OH).CH_2O.CHO \quad \text{(III)}$$
$$+2H.CHO$$

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Different Types of Hæmoglobin in Two Strains of Mice

While studying the therapeutic effect of homologous bone marrow transplantation in irradiated mice we needed a simple and sensitive technique to differentiate between the hæmatopoietic activity of the host and that of the graft. The possibility of employing differences between the hæmoglobins of our two strains of mice (*CBA* and *C57BL*) and their hybrid was suggested by the findings of Ranney *et al.*[1,2], who demonstrated two different hæmoglobin patterns in eight inbred strains of mice by using paper electrophoresis.

In the present paper the results are described of two kinds of experiments on hæmoglobin, namely, electrophoresis in agar gel and denaturation with alkali.

Agar gel electrophoresis was carried out as described by Robinson *et al.*[3] with some minor modifications. Glass plates, 82 × 82 mm., were carefully cleaned with chromic acid and provided with a coating by submerging them in 0·3 per cent agar and drying at 60° C.; 9 ml. of a 1 per cent solution of agar in 0·05 *M* citrate buffer *p*H 6·5 was poured on to each and allowed to solidify. Electrical contact between buffer vessels and the agar layer was made with filter paper strips, saturated with the citrate buffer. The hæmoglobin solutions were prepared by lysing the washed erythrocytes of 0·04 ml. of tail blood with 0·05 ml. of glass-distilled water for 15 min. at room temperature. Thereafter 0·05 ml. of citrate buffer was added and the stromata were

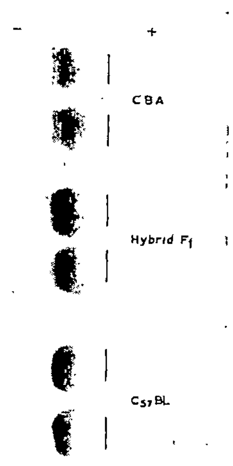

Fig. 1. Electrophoretic pattern of *CBA*, hybrid F_1 and *C57BL* mice

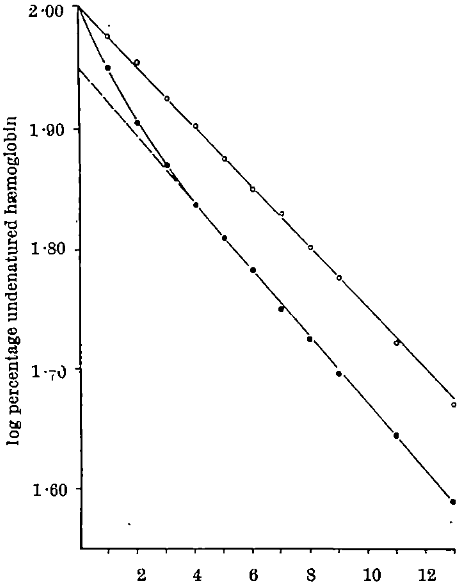

Fig. 2. Alkali denaturation of mouse hæmoglobin with 0·01 *N* sodium hydroxide. O—O—O, *C57BL* (mean of six); ●—●—●, *CBA* (mean of seven)

centrifuged down at 12,000 *g* (Servall centrifuge with the *SS*1-head, 9,600 r.p.m.). Electrophoresis was carried out in a cold chamber at 2° C., usually for 3–5 hours. The runs were made at 80 V., which resulted in a current of 19–21 m.amp. with one plate in our electrophoresis apparatus.

A typical electrophoretic pattern of mouse hæmoglobin is shown in Fig. 1, from which it may be concluded that hæmoglobin of *C57BL* mice has only one component, whereas hæmoglobin of *CBA* has two. The hæmoglobin of the hybrid F_1 (*CBA* ♂ × *C57BL* ♀) does not show a sharp boundary, but we have not been able to distinguish a second component. Recently, Dr. Mathé has informed us that a heterogeneity in the hæmoglobin of six strains of mice could be demonstrated by starch gel electrophoresis.

The alkali-denaturation velocity was measured as described by Jonxis and Visser[4] except that 0·01 *N* sodium hydroxide was used instead of 0·06 *N*, mouse hæmoglobin being much more labile to alkali than human hæmoglobin.

The results obtained with this method agree with those of the electrophoretic technique. On theoretical grounds it is to be expected that, for homogeneous hæmoglobin, the logarithm of the percentage denaturation is a linear function of time, whereas for heterogeneous hæmoglobin the function does not become linear until the more rapidly denatured component is totally converted[5]. This has been found to be the case, as may be seen from Fig. 2, which gives the denaturation curves for *C57BL* (mean of six determinations on different animals) and *CBA* mice (mean of seven). There is, however, a considerable variation in the slope of the curves for individual mice of the same strain, but the intersection of the linear part of the curves with the ordinates (percentage of slowly denatured component) gives significantly different values ($P < 0{\cdot}01$) for *C57BL*, *CBA* and hybrid F_1 mice respectively (Table 1).

Table 1. PERCENTAGE OF SLOWLY DENATURED COMPONENT OF *C57BL*-, *CBA*- AND HYBRID F_1 MOUSE HÆMOGLOBIN

Type of hæmoglobin	No. of experiments	Percentage of slowly denatured component ± *S.D.*
C57BL	6	100 ± 0·5
CBA	7	88 ± 0·7
Hybrid F_1	6	94 ± 0·8

Both methods have proved to be useful for the identification of the type of hæmoglobin in *CBA*-*C57BL* radiation chimæræ. The electrophoretic technique is preferable, because of its simplicity.

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Different Heterogeneities of Mouse Hæmoglobin according to Strains

Two different electrophoretic hæmoglobin patterns have been demonstrated by paper electrophoresis in inbred strains of mice, and these have been shown to be under genetic control[1,2]. By means of moving-boundary electrophoresis, four different peaks have been observed in strains of genetically anæmic mice (ref. 3 and Cook, J. (personal communication) has observed three major peaks and two minor ones by chromatography on 'Amberlite *X*64'). In studies on two different strains of mice by electrophoresis in gelosis, Van Bekkum, D. W., and Welling, W. (personal communication), have demonstrated in one of them the existence of a single hæmoglobin component, and in the other the existence of several components. This communication describes the different patterns obtained by starch gel electrophoresis of hæmoglobins from six inbred strains of mice.

The strains were as follows: *C57Bl6*, *C57Br*, *AKR*, Swiss, *DBA*2 and *C3H*. Blood samples were drawn from several mice in each strain by puncture of the cavernous sinus. A 10 per cent hæmoglobin solution was prepared for immediate use by Drabkin's method[4] and stored at 4° C. Electrophoretic runs were performed within 24 hr. of the venous puncture, since the spontaneous denaturation of mouse hæmoglobin seems to be much faster than that of human hæmoglobin. Starch gels were prepared according to Smithies[5] and electrophoresis performed as described by de Grouchy *et al.*[6] (*p*H, 8·5 : 6 V./cm.; 5 hr.).

Table 1. THE FOUR TYPES OF HÆMOGLOBIN PATTERN OBSERVED IN SIX INBRED STRAINS OF MICE

	Description of pattern	Name of strains
Type 1 (Fig. 1*a*)	One very important major band. Two fringes, the more slowly moving one being slightly more important	*C57Bl6*
Type 2 (Fig. 1*b*)	Two major bands One minor slowly moving band	*AKR* *C3H*
Type 3 (Fig. 1*c*)	Three major fast moving bands One minor slowly moving band A certain number of *C57Br* did not exhibit one of the two slowly moving bands, thus, two sub-groups in type 3 may exist	*C57Br*
Type 4 (Fig. 1*d*)	Three major bands Two minor bands	Swiss *DBA*2

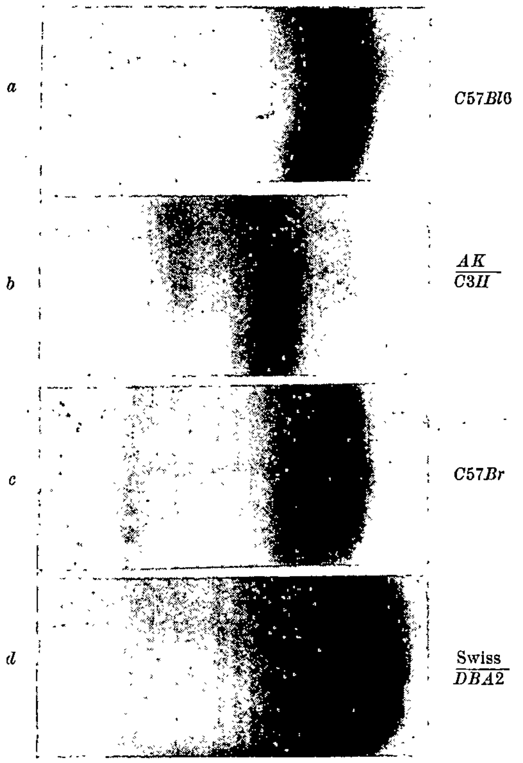

Fig. 1. Starch gel electrophoresis of mouse hæmoglobin. Four different patterns corresponding to different inbred strains

Electrophoretic patterns are characterized by a number of discrete bands which vary from one strain to another. The largest number of bands observed is five. It is thus possible to classify the seven strains of mice studied into four different groups according to their hæmoglobin pattern. Fig. 1 shows a typical pattern of each type and Table 1 is a summary of our results.

The high resolving power of starch gel electrophoresis permits the identification in mice of a larger number of hæmoglobin fractions than does paper electrophoresis or moving-boundary electrophoresis. Furthermore, it is possible to distinguish four different groups of inbred strains of mice, while only two were known previously.

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Action of Plasmin on Cartilage

Much recent work[1-4] has shown that a considerable proportion of the chondroitin sulphate in the ground substance of cartilage is combined in some way or other with protein. It is possible that the relative ease with which the mucopolysaccharide can be obtained in a protein-free form[5] by extraction with mild alkali is a reflexion of the alkali lability of some of the protein-mucopolysaccharide bonds[4]. It is also known that papain and trypsin[2,4] lower the viscosity of solutions of chondroitin sulphate–protein complex and partially remove the proteins. Plasmin is a protease resulting from the activation of serum plasminogen by diverse means, including the action of the so-called kinases of streptococci[6] and staphylococci[7,8]. In view of the chondrolytic effects of joint infections caused by staphylococci and streptococci which produce kinases, in contrast to infection by other organisms, such as the tubercle, which do not produce kinases, it seemed important to see whether plasmin preparations would liberate chondroitin sulphate from cartilage *in vitro*: such a liberation might be a step in destruction of cartilage *in vivo*.

Cartilage slices (50 mgm. wet weight) prepared from the condyles of ox femora, or from human articular cartilages, were incubated at 35° C. with phosphate–citrate buffer[9] (pH 6·2, $M/10$ with respect to phosphate) and chloromycetin (0·1 mgm./ml.) to prevent bacterial contamination, to which was added (*a*) varying amounts of a preparation of bovine plasmin (Parke Davis), (*b*) plasmin + an antiplasmin preparation. These mixtures, together with suitable controls, were incubated at 35° C. on a shaker in screw-capped bottles and at the end of varying times the fluid in the bottles was withdrawn, the cartilage slices washed with buffer and the combined washings and supernatant fluids centrifuged. The relative amount of chondroitin sulphate in the supernatant fluids was estimated approximately by two methods: (*a*) a sample of the supernatant was mixed with buffer at pH 4·2 and then acidified serum added under the conditions of Tolksdorff *et al.*[10]; the turbidity obtained was then compared with that given by known amounts of a commercial sample of chondroitin sulphate. That the turbidity obtained with the supernatant fluids was due to chondroitin sulphate was shown by incubating them with either testicular or staphylococcal hyaluronidase at pH 6·0: the former hydrolyses chondroitin sulphate, whereas the latter does not. (*b*) By hydrolysing samples of the fluids with 4 N hydrochloric acid for 4 hr. at 100°, removing the hydrochloric *in vacuo* and estimating the amount of hexosamine by the method of Elson and Morgan[11]. Table 1 shows the type of results which have been obtained with bovine cartilage. Liberation of chondroitin sulphate from bovine cartilage slices was more complete in the presence of the plasmin preparation and was stopped by so-called antiplasmin. The discrepancy between the amounts of chondroitin sulphate estimated by methods (*a*) and (*b*) presumably reflects either the lack of purity of the chondroitin sulphate standard preparation or the different degree of turbidity given by unit weights of the chondroitin sulphate liberated from the cartilage and the standard preparation. Examination of the effect of papain and trypsin on the cartilage slices showed that both of these enzymes also liberate the mucopolysaccharide. The activity of trypsin may argue against the liberation being due simply to hydrolysis of the protein associated with

Table 1. LIBERATION OF CHONDROITIN SULPHATE FROM BOVINE CARTILAGE SLICES (50 MGM. WET WEIGHT) BY BOVINE PLASMIN. The basal incubation medium consisted of 2·0 ml. of McIlvaine buffer *p*H 6·2 containing 0·2 mgm. of chloromycetin. The incubation temperature was 35°

Additions	Time of incubation (hr.)	Relative liberation of chondroitin sulphate (range in mgm.)	
		Estimation method (*a*)	Estimation method (*b*)*
None	6	0·8–1·4	—
	24	1·3–1·5	—
	42	0·5–1·5	0·2–0·5
	72	—	0·35
4 units plasmin	6	2·0–2·2	—
	24	2·0–5·2	—
	42	5·1–5·8	1·3–2·2
5 units plasmin	72	—	3·82
4 units plasmin + 4 units antiplasmin	24	0·5–0·6	0·0–0·5

* mgm. of chondroitin sulphate calculated from hexosamine estimation assuming that the mucopolysaccharide is composed of equimolar amounts of anhydro galactosamine sulphate and glucuronic acid.

the mucopolysaccharide complexes such as those referred to above, since Muir[4] finds that trypsin has comparatively little effect on the viscosity of solutions of her complex, prepared from pig tissue, although Mathews[2] reported that trypsin lowered the viscosity of solutions of his, prepared from ox tissue.

It thus appears possible that, if sufficient plasminogen is present in the vicinity of cartilage *in vivo*, activation by the kinase produced by staphylococcal and streptococcal infections may be sufficient to cause considerable leakage of chondroitin sulphate from the ground substances, with consequent damage to the mechanical properties of the cartilage.

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Experimental Suppression of Increased Capillary Permeability in Thermal Burns in Rats

THE possibility has been widely considered that œdema in thermal injury is partly due to release of substances or activation of endogenous mechanisms which increase capillary permeability. There is little convincing evidence in support of such a hypothesis, and the œdema associated with burning has never been suppressed by pharmacological means[1].

Using a modification of the method described by Sevitt[2] to produce standard burns, we have been able to confirm his observations on the development of both an immediate and a delayed œdema by subjecting rats to a standard burn (55° C. for 27 sec.) on their abdomen.

Increased capillary permeability was estimated by leakage of protein-bound trypan blue into the superficial layers of the burnt area (estimated visually on a unitary scale from 0–10) and by measuring the water content of a standard area of skin and subcutaneous tissue in the burnt zone.

In control rats, dye-accumulation in the superficial layers began about 10–20 min. after injury and reached a maximal intensity about 60–90 min. later. The accumulation of œdema in the deeper tissues developed at a slow rate and was maximal 2–3 hr. after burning (Table 1).

In rats pretreated with mepyramine maleate ('Anthisan') (1 mgm./kgm.)[3] there was a significant delay in the accumulation of dye in the superficial layers of the burnt area (Table 1). By 60–90 min., however, no difference between the control and treated animals was discernible. There was a similar, though less striking, delay in the development of subcutaneous œdema. This was apparent only in estimations made up to 1 hr. after burning. At 3 hr. after injury there was no significant difference between the œdema of the deeper tissues of the control and treated groups.

In other rats pretreated with sodium salicylate[4] (0·66 gm./kgm. body-weight given intraperitoneally 30 min. before injury), there was a striking suppression of both dye-accumulation and œdema formation, neither of which ever reached the values found in control animals.

A third group of rats was given 3 mgm./kgm. body-weight of di-*iso*propylfluorophosphonate in arachis oil intramuscularly, 30 min. before burning. Up to 30 min. after injury there was an inhibition of dye-leakage similar to that observed in rats given mepyramine. Thereafter, however, staining of the burnt area developed more slowly than in the group treated with mepyramine and in many cases never reached the intensity observed in untreated animals. Leakage of protein-bound dye was nevertheless more extensive 3 hr. after burning in the di-*iso*propylfluorophosphonate group than in the salicylate group. However, rats treated with di-*iso*propylfluorophosphonate showed a reduction in the amount of œdema developing in the deeper tissues of the burnt area when measured 3 hr. after injury, as striking as that observed in animals treated with salicylate.

Table 1. EFFECT OF VARIOUS MEASURES ON THE ACCUMULATION OF TRYPAN BLUE AND OF ŒDEMA FLUID IN THE SKIN OF RATS SUBJECTED TO THERMAL BURNS

Treatment	No. of animals	Time after burn	Water* (gm./cm.^{2} burnt skin)	Grading of blue in arbitrary units
Controls	17	30 min.	—	4·6 ± 1·7
	20	3 hr.	0·15 ± 0·03	9·5 ± 1·03
'Anthisan'	11	30 min.	—	1·7 ± 1·28 (*P* = < 0·001)
	10	3 hr.	0·15 ± 0·059 (N.S.)	9·5 ± 1·06 (N.S.)
Salicylate	12	30 min.	—	0 (*P* = 0)
	8	3 hr.	0·05 ± 0·02 (*P* = < 0·001)	2·4 ± 0·92 *P* = < 0·001)
Di-*iso*propylfluorophosphonate	8	30 min.	—	1·6 ± 0·9 (*P* = < 0·001)
	9	3 hr.	0·07 ± 0·04 (*P* = < 0·001)	5·0 ± 1·5 (*P* = < 0·001)

* Mean water content of normal skin = 0·03 gm./cm.^{2}.
—, not tested.
N.S., not significant.

Depletion of bodily histamine and 5-hydroxytryptamine by a course of injections of compound 48/80 also delayed the onset of dye-linkage into the burnt area. BOL 148, an antagonist of 5-hydroxytryptamine, caused only a slight and inconstant delay in the onset of dye-leakage.

These results, which will be published in greater detail elsewhere, are consistent with the hypothesis that delayed increased capillary permeability seen after thermal injury is due to the consecutive operation of two or more intermediary mechanisms or chemical mediators released from the tissues. They also indicate that release of histamine may be responsible for the initial phase of such a series of events. Similar results have been obtained in inflammation due to chemical irritation[3,4]. The action of salicylate and di-*iso*propylfluorophosphonate on the later stages of the reaction to burning may be due to inhibition of the activation of globulins which increase capillary permeability. However, di-*iso*propylfluorophosphonate in particular has general effects on capillary permeability which are of interest and are the subject of further investigation.

We thank Sir Roy Cameron for his interest and encouragement and Messrs. Sandoz and Burroughs Wellcome for gifts of BOL 148 and compound 48/80 respectively.

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Straight-Growth Inhibitors in Glucose

Several authors[1–5], when partitioning crude ether extracts of plant material, have saturated the aqueous phase with glucose to facilitate its separation from the ether phase.

During the course of an investigation on growth correlation inhibitors, it was found several times that extracts prepared with the addition of glucose inhibited straight growth of wheat coleoptile sections more than those without glucose. After checking other sources of inhibitory substances, it was decided to investigate the effect of glucose more fully.

Saturated solutions of glucose (usually 45 ml.) were made alkaline with an 8 per cent w/v solution of sodium bicarbonate (1–9 ml. of solution) and were shaken three times with 30 ml. of peroxide-free ether. The ether phase was discarded and the aqueous solutions acidified to *p*H 3·1 with orthophosphoric acid, and again shaken three times with 30 ml. ether. The three ether fractions were combined and reduced to 1 ml. on a water bath. Amounts equivalent to 10 gm. glucose were delivered on to Whatman No. 1 paper strips with a microsyringe[6]. Comparisons were made with extracts from 7–8 days old etiolated pea seedlings grown at 25° C. (the top inch of the stem was discarded to avoid a possible effect of indoleacetic acid on the inhibitor assay). For every 10 gm. of pea stems 1 ml. of distilled water was added to the crude ether extract, and ether evaporated and the aqueous solution filtered (Whatman No. 1). This aqueous extract was treated in the same way as the extract from the glucose solution, except that the amount of ether extract applied per chromatogram was equivalent to 20 gm. fresh weight. Chromatograms were developed in the ascending direction after an equilibration period of 6–12 hr. with the solvents given in Fig. 1. Solvents containing acetic acid were unsatisfactory, for they made the coleoptile sections flaccid and caused inhibition. This effect could not be overcome without affecting the natural inhibitors as well. Chromatograms were cut into ten equal strips, which were tested against two control strips from the same chromatogram. Nitsch's assay technique[7] was used with the minor modifications that 10-mm. sections were cut from wheat coleoptiles of the variety Cross 7.

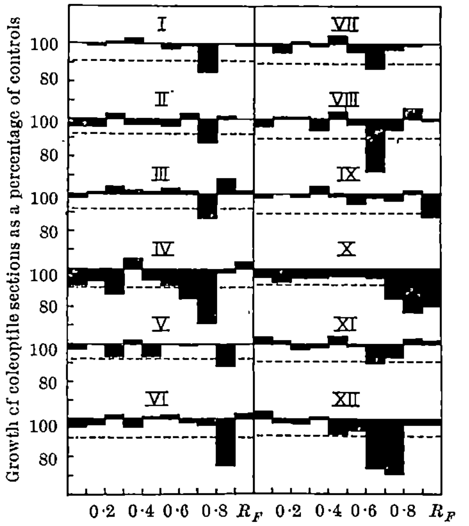

Fig. 1. The response of wheat coleoptiles to 10 gm. of different samples of glucose (I, A.R. grade; II and III, samples obtained from H. F. Stevens, Christchurch, in 1953 and 1958 respectively), and 20 gm. of stems of etiolated pea seedlings (IV); solvent, butanol/25 per cent ammonia/water (100 : 8 : 100). V–XII, glucose and peas using different solvents: V (glucose) and VI (peas), 96 per cent ethanol/25 per cent ammonia (9 : 1); VII (glucose) and VIII (peas), *iso*propanol/25 per cent ammonia/water (8 : 1 : 1); IX (glucose) and X (peas), 70 per cent ethanol; XI (glucose and XII (peas), distilled water. Growth has been plotted as a percentage of the growth of control sections; the broken line represents the level at which differences are significant ($P = 0·05$). The mean growth of control sections in different experiments was 7·88–8·84 mm. over a period of 17–18 hr.

Results are illustrated in Fig. 1. They show that all three samples of glucose of different origin (one of which was A.R. grade) contained a straight-growth inhibitor the position of which on the chromatograms was identical with that of 'inhibitor β' which occurs in etiolated pea seedlings (I–IV). The same held true for four other solvent systems (V–XII).

In another experiment the inhibitors from 250 gm. of glucose and from 250 gm. of peas were eluted from several chromatograms, and the concentrated eluates were applied to paper strips in a wide range of con-

Table 1. The Effect of the Inhibitors in Peas and in Glucose eluted from Chromatograms, at Various Concentrations

Concentration*	Growth of coleoptile sections as a percentage of controls†	
	Pea stems	Glucose
100 *G*	54·7	72·3
10 *G*	83·2	90·0
1 *G*	88·7	91·8
0·1 *G*	101·3	91·8
0·01 *G*	94·3	97·9

* *G* is equivalent to 1 gm. fresh weight of pea stem tissue or 1 gm. of glucose respectively.

† Significant differences ($P = 0·05$) from controls 10·8 and 9·5 per cent respectively.

centrations. Again, the results (Table 1) show a similar pattern for both inhibitors, although on a dry weight basis the amount of inhibition was much less in glucose than in peas.

Varga and Ferenczy[8] detected 'inhibitor β' in fruits of thirty different species belonging to ten families and the many references listed by Ferenczy[9] illustrate its widespread occurrence. This report, the fact that glucose is prepared from plant sources, and the identical position on chromatograms prepared with five different solvents suggest a possible similarity between the inhibitor found in peas, and glucose. Apart from this suggestion, this communication is intended as a warning against the use of inadequately purified glucose when partitioning extracts which are to be assayed for growth substances by the coleoptile straight growth test.

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Use of Lyophilized Formol-treated Red Cells in Blood-Group Serology

Moskowitz and Carb[1] have reported that treatment of human red cells with formalin inhibits their agglutinability without impairing their absorptive power for the corresponding blood-group agglutinin. During the course of a similar investigation, we have confirmed these findings and also the observation of Weinbach[2] that formol-treated red cells are sufficiently 'toughened' to withstand freeze-drying by lyophilization. We have found that such lyophilized cells re-suspended in normal saline retain their original absorptive capacity for blood-group agglutinins, and that eluates prepared from these cells by Landsteiner's heat method, following absorption, are as active as those from untreated cells. No hæmolysis has occurred during elution.

So far as we are aware, lyophilized formol-treated red cells have not previously been put to practical use in blood-group serology, and we wish therefore to direct attention to a practical application of this technique. We encountered recently a sample of red cells which reacted similarly to certain rare cells described by Weiner *et al.*[3] and given the symbol A_m, which showed a marked hæmolysis when we attempted to store them at low temperature in glycerol. These red cells were not agglutinated by group O immune type anti-A sera but readily absorbed anti-A. Exposure to formol-saline and lyophilization enabled these cells to be preserved satisfactorily without impairing their power of absorption and subsequent elution.

The technique we have used in the initial treatment with formalin differs in some respects from that of Moskowitz and Carb and is as follows. One volume of formaldehyde solution (analytical reagent, approximately 36 per cent w/v HCHO) diluted 1 in 30 with non-buffered normal saline is incubated at 37° C. with an equal volume of washed packed red cells. After 12–24 hr. incubation the treated red cells are washed three times in normal saline and then dried from the frozen state. If immediate lyophilization is not convenient, the formol-treated cells may be stored under distilled water at 4–6° C. Storage under distilled water has proved more satisfactory than under normal saline since, while some degree of hæmolysis tends to occur with the latter, formol-treated red cells stored for up to one week under distilled water have shown no trace of hæmolysis.

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Relationship between Certain Biological Constants and Trophic Condition in Mosquito Populations

Macdonald[1] has shown that the composition of mosquito populations, as regards the proportion in the parous state, can be calculated theoretically, yielding an equation which involves the daily survival-rate and a time period based on the gonotrophic cycle. This, and a modified equation given by Davidson[2], have provided a useful means for calculating daily survival rates in the field. Using similar methods, it is possible to derive a general expression which determines the composition of populations as regards the proportion in the unfed condition.

Assuming a population in a steady equilibrium, with a daily hatch of M mosquitoes, and a daily survival-rate of p, then the number aged x days will be Mp^x. Then let: n = days from hatch to first feed; d = days developing eggs, up to the first oviposition; f = days from oviposition to next feed; $c = d + f$.

This cycle will be repeated every c days. Then, numbering the days after emergence 0, 1, 2, . . . etc., the days on which mosquitoes are in a given state are as shown below:

Unfed	
$0, 1, 2$	$n - 1$
$n + d, n + d + 1, n + d + 2$	$n + c - 1$
$n + c + d, n + c + d + 1, n + c + d + 2$	$n + 2c - 1$
Fed and/or developing eggs	
$n, n + 1, n + 2$	$n + d - 1$
$n + c, n + c + 1, n + c + 2$	$n + c + d - 1$
$n + 2c, n + 2c + 1, n + 2c + 2$	$n + 2c + d - 1$
etc.	

Let G = number which are fed and/or developing eggs;

$$\text{then } G = M(p^n + p^{n+c} + p^{n+2c} \ldots + p^{n+1} + p^{n+c+1} + p^{n+2c+1} \ldots + p^{n+d-1} + p^{n+c+d-1} + p^{n+2c+d-1} \ldots)$$

$$= M\left(\frac{p^n}{1-p^c} + \frac{p^{n+1}}{1-p^c} + \frac{p^{n+2}}{1-p^c} \ldots + \frac{p^{n+d-1}}{1-p^c}\right)$$

$$= \frac{M}{1-p^c}\left[(p^n + p^{n+1} + p^{n+2} \ldots + p^{\infty}) - (p^{n+d} + p^{n+d+1} + p^{n+d+2} \ldots + p^{\infty})\right]$$

$$= \frac{M}{1-p^c}\left(\frac{p^n}{1-p} - \frac{p^{n+d}}{1-p}\right)$$

$$= \frac{M(p^n - p^{n+d})}{(1-p)\ (1-p^c)}$$

Let P = total population of mosquitoes ;

then $P = M(1 + p + p^2 + p^3 \ldots p^\infty)$

$$= \frac{M}{1-p}$$

Therefore, if g = proportion of the population which is fed and/or developing eggs ;

$$\text{then } g = \frac{G}{P} = \frac{p^n - p^{n+d}}{1-p^c}$$

and, if u = proportion in the unfed state,

$$u = 1 - \frac{p^n(1-p^d)}{1-p^c}$$

Two special cases may be noted, which yield simplified equations :

(*a*) where $n = f$; then $u = \dfrac{1-p^f}{1-p^c}$;

(*b*) where $f = 0$; that is, where oviposition and refeeding occur on the same night ;

$$\text{then } u = 1 - p^n$$

Thus, if the proportions u or g are known from representative samples of mosquitoes from natural resting places, a knowledge of any three of the quantities p, n, d and c allows calculation of the fourth. In practice, this will usually mean calculation of survival rate from details of the gonotrophic cycle. The method has been tested with four Malayan species of *Culex*, the survival rates of which have been estimated by other means, and close agreement has been found ; these results will be published elsewhere. This suggests that, in certain species at least, the above relationship may provide a useful means for following alterations in survival rate, for example, during control campaigns, although where anomalous gonotrophic cycles occur, for example, with a pregravid phase, the equations will require modification.

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Effect of Nitric Oxide on the Radiosensitivity of Tumour Cells

FOLLOWING the important observation of Howard-Flanders[1] that the presence of a low concentration of nitric oxide in the medium in which bacteria are suspended at the time of irradiation confers a level of radiosensitivity comparable with that of an equal concentration of dissolved oxygen, we have investigated the effects of nitric oxide on the radiosensitivity of tumour cells.

As judged by the time of appearance of tumours which arise from a standard inoculum of irradiated cells, we find that nitric oxide is capable of raising the level of radiosensitivity of anoxic tumour cells to that which they would have if irradiated in the presence of dissolved oxygen.

The Ehrlich ascites tumour cells used for irradiation were harvested from white mice (Fox) which had been inoculated five days previously with $\sim 2 \times 10^7$ cells. Since nitric oxide readily combines with hæmoglobin, erythrocytes were removed as completely as possible by two osmotic shock treatments in distilled water, terminated after 40 sec. by addition of double-strength saline. In this, and in most other respects, our technique followed closely that which had been elaborated by Scott for the study of factors which may influence the radiosensitivity of tumour cells[1]. Cells were finally suspended in saline for irradiation at 5×10^7 cells/ml. The nitric oxide was prepared by adding glacial acetic acid to a warm concentrated solution containing sodium nitrite and ferrous sulphate. After washing the gas to remove traces of nitrogen dioxide, oxygen was excluded as rigorously as possible at all stages. All cell suspensions were rendered strictly anaerobic by gas exchange with an atmosphere of oxygen-free nitrogen (British Oxygen Co.) and by their own respiration in this atmosphere before they were irradiated or treated with nitric oxide. A 4-ml. sample of the cell suspension containing 2×10^8 cells was exposed to 1,200 r. of 200 kV. X-rays filtered through 0·5 mm. copper and 1 mm. aluminium at 325 r./min. in a 'Perspex' vessel through which gas could flow (Deschner, E. E., and Gray, L. H., in preparation). In two experiments the nitric oxide was added to the saline cell suspension in the form of a solution in $1 \cdot 5\ 10^{-3}$ *M* ferrous sulphate, and a slow stream of nitrogen passed through the vessel during irradiation as a safeguard against the entry of oxygen. At the end of each irradiation or control treatment the nitric oxide was displaced by a vigorous stream of nitrogen before the cells were exposed to air. Finally, 0·2 ml. inocula from the treated fluid were introduced into each of six mice. In these experiments a control was run which showed that the effect of the mixture in raising the sensitivity of the cells was attributable mainly to the nitric oxide and not to the ferrous sulphate. In the remaining experiments the ferrous sulphate was dispensed with. Cell suspensions were brought into equilibrium with a gas phase which contained 100, 20, 10 or 2 per cent nitric oxide/nitrogen mixtures, and the same gas was passed over the cells during irradiation.

In most experiments the cells were in the presence of nitric oxide for a maximum of 15 min. Fig. 1 shows that tumours appear in animals inoculated with cells which had been treated with nitric oxide as soon as in animals which received control inocula. Contrasting this with the larger difference in the time of appearance of tumours which arose from cells irradiated in nitrogen and in oxygen, it is evident that any toxicity the nitric oxide may have had was quite insignificant as regards ultimate cell survival. Likewise, exposure of cells to 1,200 r. under completely anoxic conditions, and in the absence of nitric oxide, only slightly delayed the appearance of tumours. When, however, the cells were irradiated in the presence of nitric oxide the appearance of tumours was much delayed. In some cases, no tumours appeared at all within the 30-day observation period, and in every one of 18 irradiations in which nitric oxide was added before irradiation at an initial concentration greater than 10 μM the appearance of the tumours was delayed compared with that of tumours which grew from cells which had been treated with nitric oxide only or exposed anaerobically to X-rays. This evidence, however, is not in itself sufficient to establish the radiosensitizing action of the nitric oxide, since it is possible, in principle, that there may be synergism between the two separate

TABLE 1. EFFECT OF NITRIC OXIDE ON RADIATION DAMAGE TO ASCITES TUMOUR CELLS

		Number of mice showing ascites tumours 10 days after inoculation of 10^7 cells						
		Ferrous sulphate solution		Simple solution			Total	Per cent
	Nitric oxide concentration (when used) Nitric oxide in gas phase	10^{-3} *M**	10^{-3} *M**	2×10^{-3} *M* or 4×10^{-4} *M* 100 or 20 per cent NO/N_2	4×10^{-4} or 2×10^{-4} *M* 20 or 10 per cent NO/N_2	4×10^{-5} *M* 2 per cent NO/N_2		
Without nitric oxide	1. Control	5/5	6/6	6/6	5/5	6/6	28/28	100
	2. 1,200 r. in nitrogen	3/5	4/5	6/6	6/6	6/6	25/28	89
	3. 1,200 r. in oxygen		0/6			0/6	0/12	0
With nitric oxide	4. Nitric oxide only	6/6	5/5	6/6	6/6		23/23	100
	5. Nitric oxide before and during irradiation	2/10	0/3 1/3 6/6 6/6 0/6 0/5	3/5 0/6 5/5	2/6 0/4 0/6 0/6 0/4	0/6 2/6 6/6	33/99	33
	6. Nitric oxide after irradiation	6/6	4/5 4/6 3/6 4/6 4/6 3/3	6/6 6/6 4/6	6/6 6/6 6/6 5/6 5/6	6/6 6/6 4/6	88/104	85

* Total nitric oxide present in solution or complexed with ferrous sulphate.

injuries, namely, that due to the radiation and that due to the chemical toxicity of the nitric oxide, which could be mistaken for radiosensitization. To decide critically between these two alternatives, we concentrated most of our effort on pairs of treatments, in one of which nitric oxide was present before and during irradiation and the 'control' in which the cells were irradiated anoxically but exposed to the same nitric oxide concentration for an equal total time shortly after irradiation. Fig. 1 presents results obtained in one group of experiments in which nitric oxide was used as 20 and 10 per cent nitric oxide/nitrogen mixtures. For comparison, one group is included from another experiment to show the effect of 1,200 r. on the growth of cells irradiated aerobically.

It is quite evident that in all ten groups of animals tested in pairs, nitric oxide given before and during irradiation (broken lines) is more effective than when given after irradiation (full lines). In 4 out of 5 critical pairs, the growth of tumour cells irradiated in the presence of nitric oxide corresponded to a degree of damage as great as that which would have been sustained by cells which were aerobic at the time of irradiation. All the results obtained so far in one pilot and four principal experiments are recorded in Table 1. The figures indicate the status of mice, whether with or without tumours, on the tenth day after inoculation of 10^7 treated cells. We believe that these observations establish that nitric oxide is comparable in effectiveness with oxygen in raising the radiosensitivity of tumour cells with respect to the loss of reproductive integrity of those cells on exposure to X-radiation.

Kihlman[3] has recently reported that nitric oxide has a similar action with respect to the induction of chromosome structural damage in *Vicia* root meristem cells.

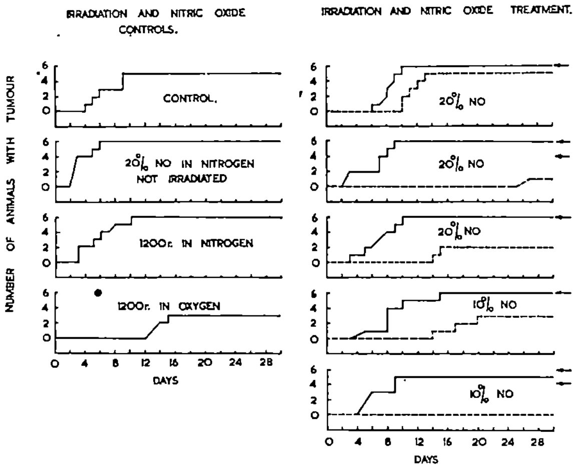

Fig. 1

The fact that there are now three known types of cell, namely, bacteria, plant meristem and mammalian tumour cells in which the molecule of nitric oxide can apparently take the place of oxygen in enhancing sensitivity to X-rays opens new means of exploring the role of oxygen itself.

We are grateful to Dr. O. C. A. Scott, who was prevented by illness from participating in these experiments, for guidance in the procedure for assaying cell survival, and to Dr. D. L. Dewey for assistance in one experiment. One of us (F. O. G.) wishes to acknowledge financial aid during the time of the investigation in the form of fellowship grants from the following groups or sources: the Jane Coffin Childs Memorial Fund for Medical Research; the Osborne Memorial Fund; the Alumni Faculty Research Fund; and the Chemistry Department of Wheaton College.

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Effect of Maize on Fat Hardness and Growth-Rate in Bacon Pigs

EIGHTEEN Large White pigs (13 females and 5 males) were fed from 100 lb. to slaughter-weight (200 lb.) on rations containing 15, 30, 45, 60, 75 and 90 per cent maize, the rest of the rations consisting of pollards, barley meal, carcass meal and minerals. The crude protein content of the rations varied from 14 to 16 per cent and the three pigs in each group were chosen at random. Feed consumption and live-weight increase were measured, and samples of fat from shoulder, back and loin were taken 24 hr. after slaughter for analysis by the Hanus method for iodine value.

The iodine values of the fats from male pigs were corrected by adding 1·7, as suggested by Lush *et al.*[1], to make them comparable with those from females. They showed wide variation within groups, and the three regression equations for per cent maize on iodine values of shoulder, back and loin fats were significant only at the 20/1 level, with low accountable variance. Nevertheless there was a definite trend in all three sets for fat hardness to decrease as the

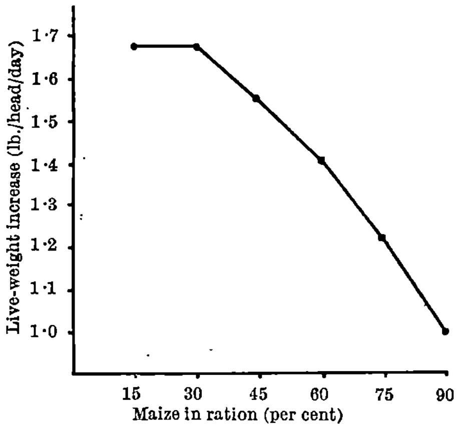

Fig. 1. Effect of maize on growth-rate from 100 lb. to 200 lb. live-weight

percentage of maize in the ration increased, although all the fats were sufficiently hard for curing into bacon and ham. In the factory the fats of 15 pigs were classed as 'very firm', and those of three 'firm', the latter being pigs on 15, 45 and 60 per cent maize.

The percentage of maize in the ration had no significant effect on the feed conversion ratio. There was a wide individual range, from 3·0 to 5·0, while group averages varied irregularly between 3·7 and 4·2. The most efficient individual conversion ratio (3·0) was obtained from a pig on 90 per cent maize, while the least efficient (5·0) was from a pig on 45 per cent maize.

There was a very striking relation between the percentage of maize in the ration and the rate of live-weight increase, and the group averages are plotted in Fig. 1, which shows a regular decrease in daily live-weight gain with increasing proportions of maize above 30 per cent. The regression equation for this relation was significant to more than 1,000/1, with 61 per cent accountable variation. This effect of maize in reducing the rate of growth probably accounts for the tendency for the fat to be softer in pigs on the high-maize rations, since Callow *et al.*[2] found that fast-growing pigs tend to have fat with a low iodine value and slowly growing pigs to have fat with a high iodine value.

The high-maize rations did not appear to lack palatability, and thus the regular decrease in the rate of live-weight gain with increasing percentage of maize in the ration suggests a nutritional deficiency in maize. Krehl *et al.*[3] concluded that zein has an unbalanced amino-acid composition which results in greatly reduced synthesis of nicotinic acid in the body and a higher requirement of tryptophan or nicotinic acid. The tryptophan contents of these rations, calculated from data by Harvey[4] and Fowden and Wolfe[5], were approximately the same, but the proportion of the total tryptophan which was derived from maize increased from 11 to 87 per cent. Nicotinic acid-deficiency in maize was reported by Braude *et al.*[6], who found that young pigs on a diet deficient in nicotinic acid and containing 79 per cent maize failed to gain weight, while another group on the same ration supplemented with 6 mgm. nicotinic acid per head per day gained an average of 5 lb. per week. They concluded that almost all the nicotinic acid in maize is in an alkali-labile 'bound' form which is not available to the pig.

From these results we suggest that the tendency for maize to produce soft fat in bacon pigs may be due to slow growth caused by a higher requirement of tryptophan or a deficiency of 'free' nicotinic acid, and that high-maize rations for pigs may require supplementary nicotinic acid. Other amino-acids may also be involved, and experiments to test these points are now in progress.

A full account of this work will be published in the *East African Agricultural Journal*.

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Temperature and Germination in *Kennedya* Vent.

During the course of studies in the genus *Kennedya*[1] it was considered desirable to determine the germination response of a range of species and ecotypes to different constant-temperature levels. Germinations were made in sand maintained at 60 per cent of the water-holding capacity. A seed was recorded as germinated when the radicle had attained a length of 5 mm. The temperatures used and some typical results are shown in Table 1.

Table 1. Total Germination Percentages after 33 days at Four Temperature Levels

Species	Line No.	10° C.	15° C.	20° C.	25° C.
1 *K. coccinea* Vent.	*G*4	93·3	94·2	80·8	46·7
2 *K. eximia* Lindl.	*E*12	61·7	72·5	55·8	25·0
3 *K. carinata* Benth. (Domin.)	*X–P*6	90·0	95·8	13·3	3·3
4 *K. prostrata* R.Br.	*A*79	78·3	89·2	5·0	0·8

Optimum temperature (that giving highest percentage at fastest rate) was generally found to be between 15° C. and 20° C. with a sharp decline at 25° C. *Kennedya carinata X–P*6 and *Kennedya prostrata A*79, however, showed spectacular decreases in germination percentage from 15° C. to 20° C. Such a dramatic effect of temperature at these moderate levels is uncommon.

Results were repeatable, and it was therefore decided to compare germination behaviour of *K. carinata* under simple alternation between 'favourable' and 'unfavourable' temperatures. Treatments were: (1) five days at 15° C., then constant 20° C. (2) five days at 20° C., then constant 15° C. (3) constant 15° C. The resultant cumulative germination percentages are shown in Fig. 1. At 21 days after commencement, treatment (1) was returned to 15° C.

It was expected that pre-treatment at 20° C. would accelerate germination at 15° C. due to more rapid imbibition at the higher temperature. However, comparing treatment (2) with (3) (control) we find that curves are essentially similar but that the former has been displaced in time. Thus rather than accelerate germination, pre-treatment at 20° C. has had a retarding effect. Treatment (1) shows that

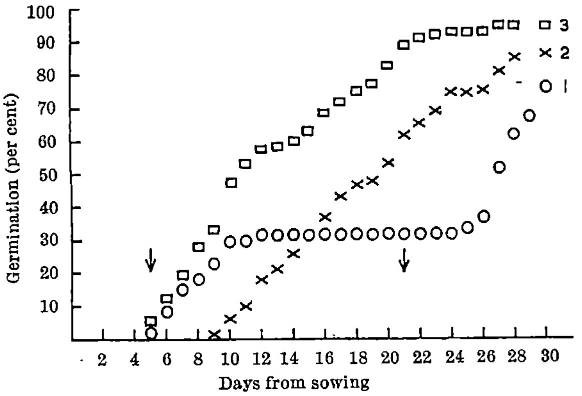

Fig. 1. Cumulative germination percentages of *K. carinata* for (1) 15–20–15° C. (circles), (2) 20–15° C. (crosses), (3) constant 15° C. (squares). Arrows indicate time of transfer

the inhibiting effect of 20° C. is not immediate in action since transfer of seeds from 15° C. to 20° C. did not at once preclude germination: there was a delay of five days before the curve levelled off. This behaviour suggests that 20° C. does not influence all phases of radicle growth but only its commencement. Once initiated in a proportion of the imbibed seeds at the lower temperature, growth continues and results in germination at the higher temperature. No further germination occurs until five days after re-transfer to favourable temperature, thus indicating that the time interval between initiation of radicle growth and completion of germination at 15° C. is approximately five days.

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Artificial Mutagenesis in Plant Breeding

MANY difficulties and disadvantages are involved in undertaking a programme of improvement of crop plants by the artificial induction of mutations. Among those which have been recognized are (*a*) the necessity for screening very large populations of plants; (*b*) the considerable degree of sterility found in mutant material; (*c*) the inefficiency of existing mutagens, and (*d*) in inbreeding forms, the desirability of isolating the frequently male-sterile R_1 generation, to avoid contamination with foreign pollen. The first of these difficulties is less troublesome in certain instances, as for example, when screening seedlings for disease resistance, for large numbers are easily handled. No doubt, for this reason, many reports[1] of the successful induction and selection of disease resistant mutants do in fact exist; resistance to *Erysiphe graminis f. hordeii* in barley, to *Puccinia glumarum* and *Puccinia graminis f. tritici* in wheat, and to *Puccinia graminis f. avenae* in oats, are among the most important.

We have recently attempted to induce in *Hordeum sativum* (variety Proctor) mutants resistant to *Erysiphe graminis f. hordeii*, and our results have indicated a still further source of uncertainty in mutation breeding.

Dormant seeds (water content 10·6 per cent) were exposed to either 10,000 rads of γ-rays from a cobalt-60 source, or to 2·2 × 10¹² thermal neutrons per cm.², and sown immediately afterwards in field plots. No other variety of barley was grown within a distance of at least one mile in any direction from the plots. R_2 seeds were sown in September, and the seedlings kept under polyethylene cages in a greenhouse. A fortnight after sowing, when the seedlings were at the two-leaf stage, a mixture of conidia, previously collected by suction pump from control plants and stored in talc at 3° C., was blown over the seedlings. Under these conditions there was 100 per cent infection of control plants (reaction type 4, scale 0–4, 4 being completely susceptible) but little sign of infection of a control resistant variety. No attempt was made to isolate the different races of the pathogen, but tests with the differential varieties of Newton and Cherewick indicated that the predominant one present was race 6. 18,490 R_2 seedlings were tested, and the frequency of chlorophyll mutations within them was as follows:

	R_2 plants	Chlorophyll mutants
γ-ray treatment	13,140	104
Thermal neutron treatment	5,350	37

No viable R_2 plant was found showing any degree of resistance to *Erysiphe graminis f. hordeii*.

These results differ strikingly from those of other workers. Hansel and Zakovsky[2], for example, found a similar number of chlorophyll mutations, as well as 190 greenhouse- and 72 field-resistant lines in 15,000 R_3 lines (R_2 ear progenies) of Volkorn barley treated with 9,400 r. X-rays. They attributed this very high rate of induction of resistant mutants to the presence of a large number of loci for this character rather than to a high mutation rate. Knowing the mutation-rate here, then from the mutation-rate of other genes in plants it might be possible to estimate the number of loci involved. If we take only the field-resistant mutants in Hansel and Zakovsky's data, they quote that the values represent two resistant mutants in every 1,000 R_2 seed. Most of the X_3 lines bred true for resistance. 15,000 R_2 ear progenies might represent 5,000 R_2 seed; 10 of these, therefore, will be mutants. Assuming 20 seeds per ear, as they do, and a 3 : 1 segregation of a gene for resistance, the ten R_2 mutant seed would be produced in at least two ears. Therefore, two R_1 ears in 250 had mutant seed (the ear initial is the unit of mutation in a seed). This value assumes no differential intrasomatic elimination of cells containing the mutant gene, and ignores the considerable number of greenhouse-resistant lines. Mutation-rates are known for very few genes in plants. Lewis[3] quotes rates from 0·008 to 0·01 per r. per 10⁶ genes for *S* alleles in *Oenothera*, after treatment of pollen mother cells with X-rays, and mutation-rates of the same order have been reported in animals and lower organisms. Though no strictly relevant figures exist, the data do allow us to draw the conclusion that in Volkorn barley there are probably many hundred loci involved in the determination of mildew resistance.

These contradictory results from two separate attempts to induce mildew resistance in barley emphasize yet another difficulty facing a plant breeder attempting to justify a programme of mutation breeding. A thorough knowledge of the genotype being dealt with, in terms of (*a*) the condition of the gene or genes controlling the character sought, that is, whether dominant or recessive, and (*b*) the number of loci involved, now appears to be of basic importance in making this decision. The fact that similar genes controlling like processes have different mutation-rates[3] is yet another complicating factor. In the absence of such information, and with our present lack of understanding of the process of mutagenesis, and of the factors affecting it, a programme of mutation breeding becomes an extremely speculative affair. The potential value of artificial mutagenesis as a technique remains, however, but a great amount of fundamental work has to be undertaken before its potentiality can be fully exploited.

We are indebted to Prof. K. Mather for guidance in the preparation of this report.

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Microbial Antagonism of *Fusarium culmorum*

DURING a survey of soil- and root-invading fungi in swards of perennial rye-grass carried out in 1956 and 1957 particular attention was given to the occurrence of *Fusarium culmorum* (W.G.Sm.) Sacc. This species, which is considered to be a soil inhabitant, is also a weak parasite of the roots of many members of the Gramineae, and during the survey it was isolated regularly from soil and from the roots of rye-grass. We find that its occurrence in both of these substrates is influenced by microbial antagonisms.

In soil, the occurrence of *F. culmorum* showed marked seasonal variations which could not be related to either soil temperature or moisture considered separately. There was, however, indication of an interaction between these factors. With high soil moisture the abundance of *F. culmorum* was positively correlated with rising temperature. At low moistures, on the other hand, there appeared to be strong inhibition above 8–9° C. These observations were substantially confirmed in an experiment in which unsterilized soil, taken from the rye-grass swards, was incubated under a range of moisture and temperature conditions. Again it was found that under low-moisture conditions there was marked reduction in the recovery of *F. culmorum* at temperatures above 10° C.

This effect of temperature is not a direct one, for the fungus grows well at high temperatures in soil with a low-moisture content. Its interaction with *Trichoderma viride*, which was abundant in the soil investigated, was, under low-moisture conditions, very striking and appears to account for the observed results. When *F. culmorum* and *T. viride* were grown together in soil at a moisture content of 40 per cent m.h.c., *F. culmorum* was dominant up to temperatures of 10° C. Above this temperature, however, it was completely suppressed by *T. viride*.

In a study of the pathogenicity of *F. culmorum* towards rye-grass a bacterium was found to be regularly present on the root surfaces, particularly of healthy roots. It was noted that this bacterium was antagonistic to *F. culmorum* on agar plates, and this aspect was investigated further. Surface sterilized seeds of rye-grass were sown in sterilized soil which had been inoculated with *F. culmorum* alone, *F. culmorum* + bacteria, and bacteria alone. It was found that under these conditions *F. culmorum* alone produced root browning accompanied by withering of the leaves, whereas in the presence of the bacterium the symptoms were substantially reduced. No pathological symptoms were observed in the seedlings raised in soil inoculated with the bacteria alone.

There can be little doubt that the bacterium is restricted to the rhizosphere. Although it was abundant on root surfaces it was only occasionally isolated from soil where its sporadic occurrence might well be expected since small root fragments would inevitably be present. The existence, in the rhizosphere, of organisms antagonistic to root pathogens has long been suspected and was apparently first suggested by Hiltner[1]; but there has been little experimental evidence to support this view. Hitherto the only cases of protective effects by rhizosphere populations have been attributed to the antagonistic effects of *T. viride*, which is preferentially favoured by the rhizosphere environment of certain plants[2].

The nature of the bacterium has been investigated and has been shown to be a polarly flagellated organism with the typical morphology and flagellation of a *Pseudomonas* and the biochemical reactions of a *Klebsiella aerogenes*[3].

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Induced Swarming of a Nematode as a Means of Isolation

SINCE nematodes extracted from soil usually comprise a mixture of species, the isolation of a pure species population for experimental purposes is frequently a laborious procedure involving the picking of individual specimens from a suspension. The tendency of *Tylenchorhynchus martini* Fielding 1956 (Nematoda, Phasmidia) in aqueous suspensions to swarm (congregate in masses) has been used to obtain large numbers of this nematode relatively free of other species. In a series of tests, mixed populations of *T. martini* and other nematodes were extracted from soil around rice plants and incubated overnight in aqueous suspensions in Petri plates. The resultant masses of *T. martini* were observed under a dissecting microscope, carefully removed with a suction pipette and transferred to a small quantity of water in an Ehrlenmeyer flask. The nematodes were dispersed by shaking and then transferred to water in Petri plates for re-incubation. This procedure has been repeated several times with no apparent loss in swarming intensity, although about 5 per cent of the population of *T. martini* in each test does not swarm and is lost in subsequent transfers. Suspensions of 50–100 thousand nematodes of 70–80 per cent *T. martini* have been purified in two serial swarmings to more than 99 per cent *T. martini*, with a virtual elimination of organic and mineral debris. Factors which stimulate swarming include a high proportion of active *T. martini* in the mixed population and a suspension density such that the individual nematodes of this species are in contact in a shallow aqueous layer. A range of room temperatures and of water reactions varying from *p*H 3·5 to 7·5 have not influenced swarming intensity.

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Cardiac Glycosides and Thyroidal Iodide Transport

DURING the past few years, it has become apparent that an important action of the cardiac glycosides involves the transport of potassium ions into the cell. It has also become possible, by the use of potassium-depleted erythrocytes, to test the relative inhibitory potency of such glycosides or their aglycones *in vitro*[1,2]. Approximately 80 per cent of the potassium influx can be inhibited by the glycoside by an action that appears to involve competition by drug and potassium ions for the active transport site. The transport of chloride ions in the stomach appears to be similarly affected[3]. Since the maintenance of a concentration gradient for iodide by an 'active transport' is one of the fundamental properties of thyroid tissue, we determined whether or not iodide transport was likewise inhibited by the cardiac glycosides.

Sheep thyroid slices (~150 mgm.) were incubated for 70–90 minutes at 37° C. in Krebs–Ringer phosphate medium (3 ml.), *p*H 7·4, containing 10^{-3} *M* 1-methyl-2-mercaptoimidazole, to block organic iodine formation, and 0·2–0·3 μc. of carrier-free iodine-131. The iodine-127 content varied from 0·15 to 0·20 μgm. per 100 ml. Cardiac glycosides were dissolved in absolute ethanol, diluted with water and added to the flasks as 0·1 of the final volume to yield a final ethanol concentration of 1–2 per cent. Controls received equivalent quantities of ethanol. Results are expressed as the ratio of iodine-131 content per gram of tissue to the iodine-131 content per ml. of medium (*T*/*M* ratio).

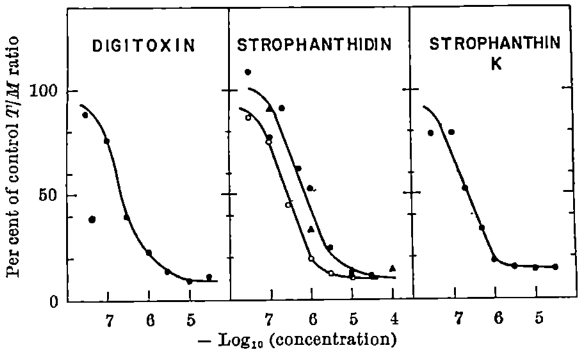

Fig. 1. Effect of cardiac glycosides on the thyroid/medium ratio (*T*/*M* ratio) of iodine-131 in sheep thyroid slices. The control *T*/*M* ratios varied from 12–25 : ● and ▲, experiments 1 and 2, fitting approximately the same curve; ○, experiment 3

Table 1. INHIBITION OF IODIDE TRANSPORT BY CARDIAC GLYCOSIDES

	Concentration for 50 per cent inhibition of the *T*/*M* ratio* (*M*)	
	Sheep thyroid slices	Rat tumour slices
Digitoxin	2×10^{-7}	$1·5 \times 10^{-4}$
Strophanthidin	$2–5 \times 10^{-7}$	9×10^{-4}
Strophanthin *K*	2×10^{-7}	

* Incubated at 37° C. under air in Krebs–Ringer phosphate buffer, *p*H 7·4, for 70–90 min.

The results, depicted in Fig. 1, demonstrate that two glycosides, digitoxin and strophanthin *K*, as well as the aglycone strophanthidin, all depress the *T*/*M* at concentrations comparable to those found to inhibit potassium transport. For strophanthidin, the results of three separate runs show the variation in responsiveness that occurs between different batches of glands. The inhibitory potency of the drugs can be compared at the point of 50 per cent inhibition (Table 1). The order compares more closely with that of Solomon *et al.*[2] than that of Kahn and Acheson[1]. The concentrations for 50 per cent inhibition are probably somewhat lower, since the curves do not go below 10 per cent of the control *T*/*M* value (Fig. 1).

We have recently described a thyroid tumour in rats in which the iodide-concentrating mechanism survived without the further steps in hormone synthesis[4]. As shown in Table 1, the iodide concentrating mechanism of these tumours is about 1,000-fold less sensitive to the cardiac glycosides than is normal sheep thyroid tissue. Another tissue that normally maintains an iodide gradient is the submaxillary gland of mice[5]. Preliminary experiments with submaxillary glands of *C3H* mice have yielded variable results : no inhibition at 10^{-4} *M* strophanthidin and 30 per cent inhibition with 10^{-4} *M* digitoxin. We were, however, not able to obtain mice with salivary *T*/*M* ratios as high as those previously reported.

The above results indicate that thyroid tissue transports iodide by a system that is sensitive to inhibition by the cardiac glycosides. The kinetics of the inhibition and the relation of iodide to potassium transport are now under investigation.

We should like to thank Dr. J. E. Rall for his advice during the course of this work, and I. L. Cooperstein for permitting us to see the manuscript of ref. 3 prior to publication.

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Spontaneous Electrical Activity in the Denervated Muscles of the Cockroach *Periplaneta americana*

SPECIAL features of the anatomy and physiology of the invertebrate neuromuscular junction raise the question of to what extent the changes caused by denervation of the insect muscles are analogous to those in the denervated muscles of vertebrates.

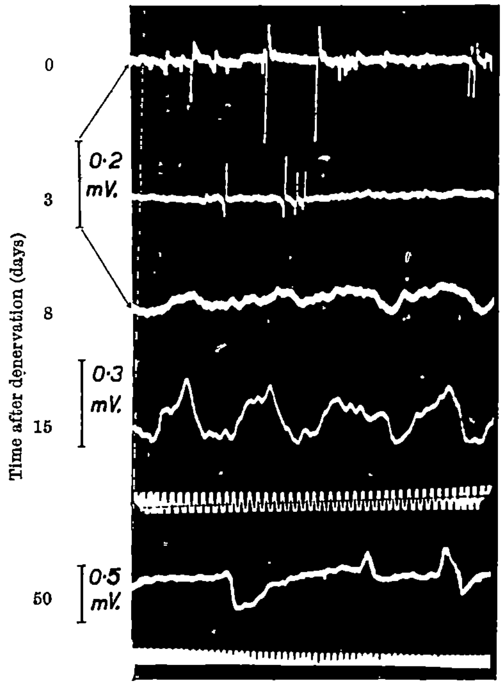

Fig. 1. Development of spontaneous electrical activity in the femoral muscles of the cockroach after denervation. Time scale: 500/sec.

Experiments were carried out to ascertain whether denervation of insect muscle is followed by spontaneous activity comparable with the well-known fibrillations in the denervated striated muscles of vertebrates. Voskresenskaya[1] described rhythmical spontaneous twitches in the extremity of the locust as early as the first day after denervation. Recently, Case[2], in visual observations of the denervated muscles of the abdominal spiracles of the cockroach, found "nearly continuous slow contractions and relaxations of small groups of muscle fibres" and called this phenomenon fasciculation. In the present experiments, the electrical activity of the denervated insect muscle was studied.

Adult males of *Periplaneta americana* (L.) were used. One extremity was denervated by cutting the nerves between the metathoracic ganglion and the left leg. Action potentials were recorded for the coxal and femoral muscles 0, 3, 8, 15 and 50 days after denervation. Monopolar insulated steel electrodes with a tip of approximately 35μ inserted through the chitin were used throughout the experiments. To prevent artefacts due to possible movements of the intact parts of the animal, the recording was performed on a metathoracic preparation obtained by isolating the metathorax with the extremities from the abdomen and the rest of the thorax. The open tracheæ ensured good metabolic conditions in this preparation.

Immediately after denervation, spontaneous electrical activity appeared as frequent pulses of short duration. Their duration (0·6–0·8 msec.) suggests their nervous origin. They were less frequent on the third day after denervation and from the eighth day they were replaced by a new type of activity, which was characterized by waves of 6–14 msec. duration with superimposed deflexions of 3–5 msec. The large waves became more numerous and increased in amplitude with time after denervation. The activity was irregular, of varying amplitude and disappeared and reappeared gradually at irregular intervals of 0·5–3 min. (50 days after denervation distinct long-duration spikes could be distinguished in the record, but at this time interference due to re-innervation cannot be excluded[3].)

It is presumed that the observed potential changes are an expression of spontaneous activity in the denervated muscle fibres with a varying degree of synchronization. They differ from the electrical activity of denervated vertebrate muscles, as was shown by a recording from the denervated tibial muscle of the rat using the same electrode, where only the usual short-duration spikes of individual fibres could be detected. When evaluating the denervation activity in the cockroach, it must be remembered that this can be the result of simultaneous potential changes in the various elements (slowly and fast contracting fibres) of the insect muscle.

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Influence of Trace Elements upon Plant Protein Composition

Mulder's work[1] has shown that whereas macro-elements did not alter the amino-acid composition of potato protein, they did significantly alter the amino-acid composition of its soluble non-protein nitrogenous fraction. The influence of micro-nutrients on the amino-acid composition of plant proteins has not been properly studied, although there is evidence which suggests it might be appreciable[2]. There is, in fact, reason for believing that micro-elements may alter the relative proportions of the amino-acids in

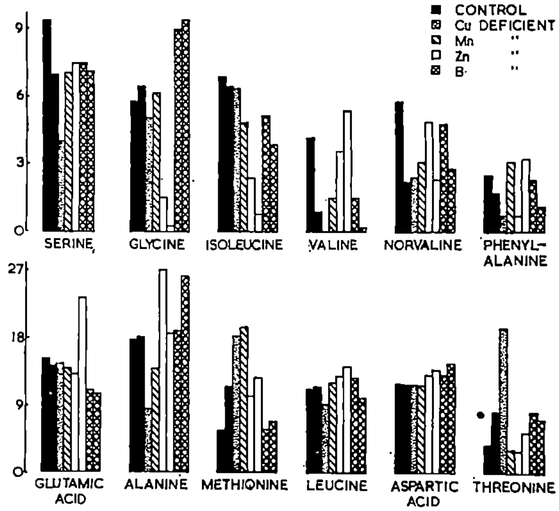

Fig. 1. Amino-acids of digests of plants deficient in trace elements as percentages of total amino-acids present. There is no detectable valine in the copper-deficient plant. One of the serine samples in the zinc-deficient plants was lost. Only single estimations of copper- and manganese-deficient plants were undertaken

plant proteins. If such is the case, this effect would be of great interest in animal and human nutrition, especially since deficiencies in trace elements are widespread[3], as is infant protein malnutrition (kwashiorkor), which appears to be primarily the result of amino-acid deficiency[4].

In a pilot study, beans (variety, Victory Dwarf Bush) were grown on Robbins's nutrient solution[5], and on this solution lacking in boron, copper, manganese and zinc respectively. They were harvested when the first fruits appeared, and the proteins were extracted according to the method of Lugg[6]. The proteins were hydrolysed for 12 hr. in 6 *N* hydrochloric acid and the amino-acid content of the hydrolysate was estimated by a semi-quantitative chromatographic method devised by one of us (H. E. S.). The results are recorded in Fig. 1.

There are indications in this preliminary investigation suggesting that beans grown in a copper-deficient medium have a higher concentration of threonine and perhaps a lower concentration of valine in their protein than normal, whereas beans grown in a zinc-deficient solution have proteins with a very low level of glycine and perhaps *iso*leucine. Confirmatory experiments are in progress on these and other plants.

We acknowledge the technical assistance of Misses H. Lenz and N. Posthumus.

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Retention of Food Residues in the Midgut by Nymphs of the Milkweed Bug, *Oncopeltus fasciatus* Dall.

During experiments on the nutrition of *Oncopeltus fasciatus*, in the course of which both nymphs and adults ingested solutions containing a fine suspension of Chinese black, it was noticed that only the adults voided black fæces, and that newly moulted adults voided a particularly thick black mass within two days of ecdysis. In a confirmatory experiment, the insects were reared from the egg on milkweed seed and a water-suspension of Chinese black, and their excreta were collected on the filter paper shown in Fig. 1. By the time the first adults had appeared, only watery material had been excreted, whereas three days later, when nearly all had moulted, black fæcal masses were evident.

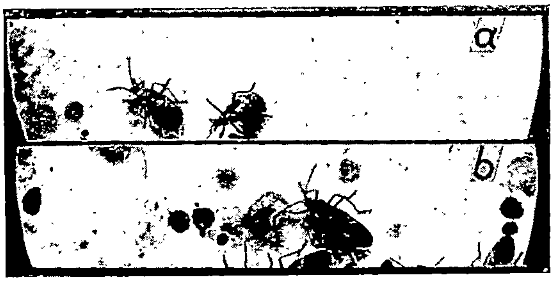

Fig. 1. The accumulated excreta of *Oncopeltus* reared on milkweed seed and a water-suspension of Chinese black: (*a*) just before and (*b*) after the majority had become adult

Examination of the nymphs showed that particles of Chinese black became concentrated in the third region of the midgut. It was also found that in mature nymphs which had fed on an abundance of milkweed seed, whether or not they had ingested Chinese black, this region was distended, had a flourishing bacterial flora, and contained a large droplet of oil. The short, narrow region (which has been called a 'fourth stomach'[1]) connecting the third region of the midgut to the 'pylorus' appeared, at this stage, to be histologically fully formed, but closed, although traces of a lumen could be made out along most of its length. In adults, the third region of the midgut did not reach the dimensions of that in the mature nymph, its bacterial flora was greatly depleted, and it was never found to contain a droplet of oil.

It appears, therefore, that in *Oncopeltus* the residues of nymphal meals accumulate in the third region of the midgut, to be voided soon after the final ecdysis. This does not seem to have been recognized previously, possibly because the nymphs excrete drops which contain reddish-brown solid matter, and these can be mistaken for true fæces, although they lack the thicker consistency of the latter and almost certainly originate entirely in the Malpighian tubes.

Many phytophagous Heteroptera possess special features associated with the last region of the midgut, such as cæca or inwardly directed filaments[2], which are lacking in *Oncopeltus*. It would be interesting to know, therefore, whether, in these cases, food residues are also retained in the nymphal midgut, since it is possible that the retention in *Oncopeltus* is concerned with ensuring the efficient extraction of nutrients from a simpler form of gut.

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Composition of the Cell Wall of *Staphylococcus aureus* 209P

Recently, Park and Strominger[1] assumed that uridine-diphosphate compounds extracted from cells of *Staphylococcus aureus H* treated with penicillin are the precursors of the cell wall, because the cell wall and one of their compounds contained muramic acid, alanine, glutamic acid and lysine in the ratio of 1 : 3 : 1 : 1. But the cell wall also contained glycine (ratio 3 : 8).

We found[2] that similar uridine-diphosphate compounds were accumulated in another strain of *S. aureus* treated with penicillin, but these compounds contained five amino-acids: alanine, glycine, lysine, aspartic and glutamic acid in various combinations. As it seems probable that there is a certain variation in the amino-acid composition of cell walls among different strains of a single bacterial species[3], a study was made of the amino-acid composition of the cell wall of the present strain to confirm the assumed correlation between the accumulated compounds and cell walls.

Table 1. Amino-acid Content of Hydrolysates from the Bacterial Cell Wall of *S. aureus* 209*P*, expressed in No. of Molecules (Muramic Acid referred to as 1)

	Molecules		Molecules
Muramic acid	1·0	Aspartic acid	0·6
Alanine	1·6	Leucine	0·8
Lysine	1·0	Serine	0·7*
Glutamic acid	0·8	Threonine	0·3
Glycine	2·3	Valine	0·4

* This is probably a maximum value, since serine was only incompletely separated from glycine on the paper chromatogram.

Using the method of Cummins and Harris[4], cells of *S. aureus* 209*P* were ruptured with a Mickle disintegrator, the homogenate was centrifuged off the intact cells at 3,000 r.p.m., and the supernatant was further centrifuged at 10,000 r.p.m. The precipitated cell-wall fraction was treated successively with trypsin and pepsin, and hydrolysed with 6 *N* hydrochloric acid for 6 hr. at 120° C. Amino-acids in the hydrolysate were separated by two-dimensional paper chromatography using the method of Levy and Chung[5]. Ninhydrin-positive spots were cut out from the paper, eluted, and determined by the method of Rosen[6].

As shown in Table 1, not only muramic acid, alanine, lysine and glutamic acid but also glycine, aspartic acid and leucine (and/or *iso*leucine) were predominant. The undigested cell-wall fraction contained considerable amounts of valine and threonine, and the whole cells contained also proline, phenylalanine, histidine, methionine and tyrosine. This evidence shows that the same five amino-acids are found both in the cell wall and in the present compounds as main components. Furthermore, it was found that the main species of peptides linked with uridine-diphosphate-N-acetyl muramic acid were peptides composed of three alanine, two lysine and one glutamic acid residues, and of two alanine, two lysine, two glycine, one glutamic acid and one aspartic acid residues (Ito, E., Ishimoto, N., and Saito, M., unpublished work).

This evidence seems to support the assumed correlation between the accumulated compounds and cell walls.

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Sagitta as a Host of Larval Trematodes, including a New and Unique Type of Cercaria

It has long been known that *Sagitta* may occasionally foster young trematodes, but we have learned very little since Müller, Busch, Leuckart and Pagenstecher made discoveries of this kind more than one hundred years ago. During the present century, Miss M. V. Lebour found two species of Digenea in *Sagitta bipunctata*[1]. Small *Derogenes varicus* (Hemiuridae) were seen near the ovary, generally singly, and post-larval *Opechona bacillaris* (Allocreadiidae) were seen in the gut as well as near the ovary, indicating that migration into the cœlom takes place through the wall of the intestine. Young forms similar to *Derogenes* have been found in the body cavity of unspecified chætognaths in South Australia, and small yellow cercariæ in the cœlom of *Sagitta enflata* were recorded but not described. Small appendiculate Hemiurids have been seen in *S. elegans* at Woods Hole and in *S. enflata* from the Bay of Algiers, and forms identified as small *Hemiuris communis* have appeared in *S. elegans* and *S. setosa* from Northumbrian plankton. Young forms of a rarer trematode—some unnamed member of the Accacoeliidae and possibly a species of *Tetrochetus*—have been found in *S. enflata* from the Indian Ocean near Madras[2].

Any trematode larvæ which gain entry into *Sagitta* may, it seems, with equal facility enter planktonic cœlenterates and copepods, and post-larval Hemiurids, Accacœliids and other Digenea have been found in such hosts. Heavy infections have been reported in siphonophores. In an infection of *Physalia utricula* with an unnamed Accacœliid near Japan, "les plus petits spécimens . . . de 5 mm. de long, ont déjà abrité un grand nombre de parasites dans leur polypes en développement, ainsi que dans diverses parties de leur poche aérienne"[3]. It is difficult to see how a fish could be infected through the agency of such a virulent vector, but it is evident that close co-operation between students of the plankton and parasitologists is necessary for the acquisition and study of the life histories of some of these elusive trematodes.

By the kindness of Dr. John Colman, I have been privileged to examine a number of parasitized *Sagitta* collected on the *Rosaura* Expedition[4]. Two specimens of *S. tenuis*—one from Barima River, Morowhana, and the other from Demerara River, Georgetown—contained a small appendiculate Hemiurid, which is probably a species of *Hemiuris*, and a very young larval cestode respectively. One *S. hexaptera* from the northern edge of the North Equatorial Current contained numerous multinucleate, non-helminthic parasites which are as yet unidentified. Twelve other *S. hexaptera*, collected in various localities in the Caribbean—between Cuba and Jamaica, off Roatan Island, some 250 miles N.N.W. of Colon, and off Puerto Columbia—contained a total of 15 larval trematodes of the same kind. Three hosts had two parasites each, the remaining nine hosts one apiece. Two of the larvæ were located in the intestine, the remaining 13 in the body cavity.

These larvæ have been seen only once hitherto and they are cercariæ, not metacercariæ. Each has two cylindrical posterior appendages with rounded distal extremities and very narrow connexions with the body (Fig. 1). They are undoubtedly identical with the forms called *Metacercaria owreae*, but they reach a larger size and show greater variability. The range of length × breadth is 0·3 × 0·2–1·2 × 0·7 mm., that of diameters of the oral and ventral suckers 0·07–0·24 mm. and 0·12–0·37 mm. The posterior appendages are not almost exactly half as long as the body in large and small specimens alike, as previous measurements indicated[5]; instead, they are of extremely variable length (0·25–1·45 body-length) and not proportionate to the size of the body.

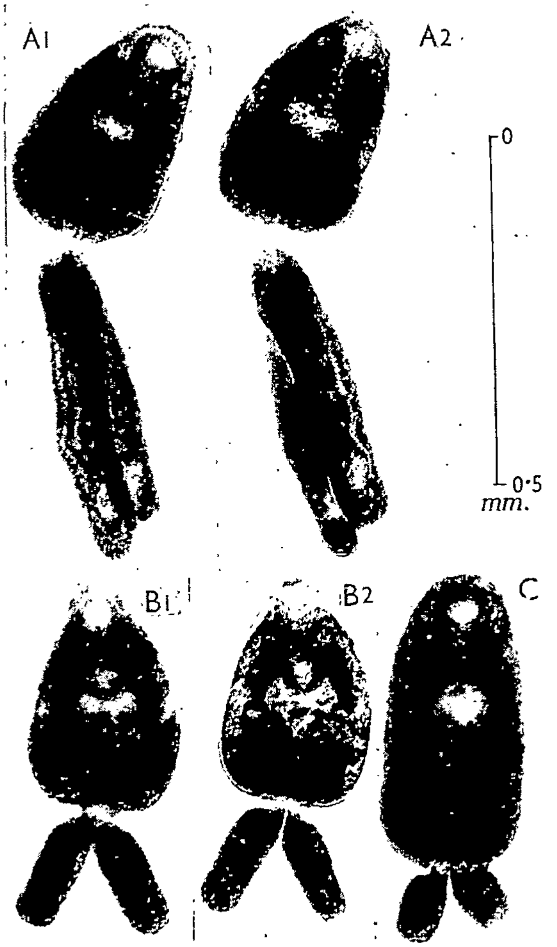

Fig. 1. *A*, *B* and *C*: three cercariae from three *Sagitta hexaptera* taken 250 miles north-north-west of Colon. In *A*1 and *B*1 the focus is on the ventral sucker; in *A*2 and *B*2 on the pharynx and the gut caeca. Actual body-lengths: *A*, 0·34 mm.; *B*, 0·33 mm.; *C*, 0·43 mm. Note the varying length of the posterior appendages; 0·4 mm. in *A*, 0·2 mm. in *B* and 0·1 mm. in *C* (approx.)

I can confirm the observation that a prolongation of each cæcum extends into the corresponding appendage—so that the term 'tail' is inadmissible—and I affirm that the corresponding adult must therefore possess a pair of anal openings. This unusual condition is known in only a few trematodes, but among these are the seven genera of the Accacoeliidae[6], and in this instance it must arise as a consequence of loss of the appendages during post-larval development. Another notable character, not observed hitherto, is the existence of short anterior extentions of each cæcum in the form of six very short and rudimentary diverticula, which form a kind of rosette at the tip. These are indications that this larval Accacoeliid probably belongs to the genus *Accacladocoelium* Odhner, 1928, but to which of four known species is uncertain because of the state of immaturity, although *A. petasiporum* Odhner, 1928, may be ruled out by the form of the ventral sucker. Older specimens with shrunken appendages or without appendages show peculiarly fine annulations indicative of *A. nigroflavum* (Rud., 1819).

New specimens of *Cercaria owreae* will not be easy to find, unless the following point regarding distribution proves helpful. Hitherto, only 8 specimens were found in 5,767 specimens of *Sagitta enflata*, *S. hexaptera* and *S. lyra*. The total incidence of infection was given as 0·14 per cent, the incidence for respective species 0·09, 0·14 and 1·15 per cent, no other figures being given. My specimens were obtained from 290 *S. hexaptera*, but 109 hosts of this aggregate which were collected off the north coast of Brazil and in the Central Atlantic did not contain any parasites; all 15 larvæ were obtained from 181 *S. hexaptera* collected in the Caribbean localities specified. Moreover, no parasites were found in 141 *S. enflata*, 110 *S. lyra* and 167 *S. maxima*, which are all transparent species in which any parasites could have been readily seen. The *Rosaura* hauls of *S. hexaptera* were made in open nets between 1,250 m. and the surface, although this is a species living mainly between the surface and 100 m. The first intermediate host of this trematode is presumably a bottom-dwelling mollusc of coastal waters, and the posterior appendages are probably organs of flotation which bring emergent larvæ into the realm of the plankton. The re-appearance of the pelagic larvæ may be anticipated in the Caribbean plankton and that of the Florida Current, probably also in that of the Gulf of Mexico and other localities. They must be sought as free forms, as parasites of species of *Sagitta* and as parasites of other planktonic animals such as coelenterates and copepods. The definitive host is most probably the sunfish *Mola mola* (L.) but it may well be some other oceanic fish which feeds on plankton. Infection will result from the ingestion of planktonic vectors containing larvæ, possibly from the ingestion of free forms.

I wish to thank Mr. A. T. Green of King's College for taking the photographs.

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The Saw-Fish of Sierra Leone

There are three species of saw-fish which are occasionally caught along the coast of Sierra Leone. These are *Pristis pectinatus* (Latham), *Pristis pristis* (Linn.) and *Pristis peroteti* (M. and H.). The majority of captures have been made within the rivers, river mouths and from the open beaches; but as few of the captures have been subjected to any critical examination, practically nothing is known about the habits of saw-fish in Sierra Leone waters.

According to Copley[1], *Pristis pectinatus* and *Pristis peroteti* regularly ascend quite a long way up the Sherbro River when the river is in flood, and return to the sea on the falling of the waters. Whether this is a spawning migration has not yet been confirmed. The same species have also been caught in the Sierra Leone River, which is about 60 miles to the north of the Sherbro River, by the West African Fisheries Research Institute during trawling operations during 1952–57. They are also to be found more frequently in the Sierra Leone River when the river is in flood.

Saw-fish sometimes become entangled in the nets of the local fishermen, causing considerable damage to both nets and catch. For this reason, they are regarded as pests rather than a source of food, in spite of the fact that there is a ready market for the flesh. In the Keta district, Ghana, the 'saw' is removed and used for fetish purposes, being specially coloured alternately red, white and blue colours[2]. It does not, however, appear to have any religious significance for the fishermen of Sierra Leone.

During the course of a fish-marking cruise in May, a male specimen of *Pristis peroteti* was caught in the Sierra Leone River, about ten miles from the mouth. This fish weighed 257·6 kgm. and measured 4·42 m. from the tip of the 'saw' to the end of the caudal fin. The liver yielded more than 13 litres of oil, and within the stomach was found a 52-cm. 'whiting' (*Cynoscion brachygnathus*, Bleek), which was in a fair state of preservation and showed wounds caused by the 'saw'. There was a deep cut on the left side, about 19·5 cm. long, in front of the operculum and a stab wound in the flesh of the back in front of the dorsal fin. There was no other food material either in the stomach or the intestine of this saw-fish.

Although saw-fish may occasionally use the 'saw' as a defensive weapon, its main purpose is to obtain food. This it does by grubbing about on the bottom in its search for small fish and crustaceans lying buried there. It may also use the 'saw' as a weapon of attack, as the present instance shows; but it probably does so only rarely in the estuaries of Sierra Leone as the water is usually very turbid. In this connexion, it is interesting to note that the specimen under consideration was caught at the end of the dry season (May), when the waters of the Sierra Leone River are at their clearest.

J. C. D. Watts

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[1] Copley, H., "The Game Fishes of Africa" (H. F. and G. Witherby' London, 1952).

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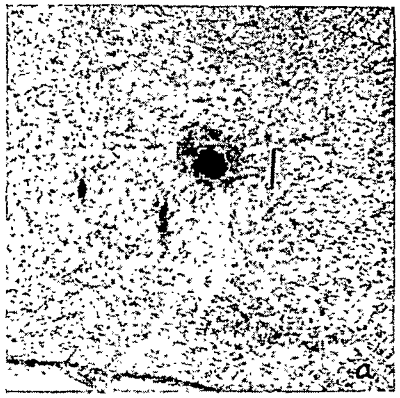
A Simple Microelectrode for recording from the Central Nervous System

Metal microelectrodes suitable for recording from single cells externally or after penetration have been described by various authors[1–3]. The procedures of Svaetichin[2] and Grundfest[1] call for special apparatus, and the method of Hubel[3], employing tungsten, in our hands gives rather noisy electrodes which are difficult to straighten. Steel electrodes, which have the advantages of low noise, low electrode potential, ease of straightening and, in particular, offer the possibility of accurate localization of the recording site, may be made as follows.

Stainless steel insert pins size 00, which are about 1·5 in. long (Clay-Adams Co.), are used. Using a filament transformer of 7 V. output, regulated by a variable auto-transformer, the terminal 1 cm. is thinned with alternating current against a carbon electrode dipped in concentrated hydrochloric acid. The surface of the acid is covered with xylol to limit the highly corrosive spray. The voltage is then reduced to about half and the tip quickly agitated up and down through the xylol–acid interphase. A highly polished and very sharp tip is produced. A terminal thickness of less than 0·5μ is readily obtained (Fig. 1*b*). Residual acid must be removed quickly to avoid pitting, so the electrode is quickly dipped in strong sodium carbonate solution and then successively in 1 per cent acetic acid, alcohol and xylene. Insulation is obtained in a manner similar to Hubel's technique[3]. While the electrode is wet with xylene, it is pushed beneath the surface of unthinned lacquer (Insl-*X E*33 clear, Insl-*X* Co., Ossining, New York), held beneath the surface for 30 sec., quickly withdrawn, inverted and allowed to dry at room temperature for 2 hr. It is then baked overnight at 60° C. Electrode resistance ranges between 5 and 100 megohms. Cells may be successfully penetrated, and extracellular spikes of up to 10 mV. with good rise times have been recorded from neurons in the hypothalamus, indicating reasonable electrode capacitance. The recording site may be marked by a current of about 2 μamp. for 15–30 sec. If the electrode is made the anode, a small amount of iron is lost. (The insulation may then be observed under the microscope as a transparent terminal core.) The animal is fixed in 10 per cent formalin with about 1 per cent potassium ferrocyanide added. A prussian blue spot is obtained. The large deposit shown in Fig. 1*a* was made by a much larger current (100 μamp. for 10 sec.), but this is unnecessarily large.



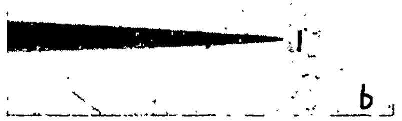


Fig. 1*a*. Site of recording marked by prussian blue reaction. Two earlier tracks to right. Mark = 200μ (100 μamp. for 10 sec.)
Fig. 1*b*. Electrode tip. Oil immersion. Mark = 2μ

It may be noted that if the lacquer advised is not available, a lacquer of high viscosity with a tendency to form a surface pellicle rapidly is desirable. This avoids beading and, while the electrode is inverted, the coat becomes thin as the central lacquer is still capable of flowing away from the tip beneath the surface pellicle. Lacquer shrinkage in the final setting determines the size of the exposed tip.

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July 28.

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[2] Gray, J. A. B., and Svaetichin, G., *Acta Physiol. Scand.*, 24, 278 (1951).

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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, October 6

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. R. O. Kapp: "Space" (Chairman's Address).

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. Keith H. Best: "Bridge Over the River Kwai".

Society of Chemical Industry, London Section (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. W. S. Wood: "Some Developments in the Field of Chemical Propellents" (Chairman's Address).

Tuesday, October 7

Society for Visiting Scientists (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "The Metric System in Great Britain". Chairman: Sir Charles Darwin, F.R.S. Speakers: Dr. A. H. Hughes, Sir Graham Savage, C.B., and Dr. H. Barrell.

Wednesday, October 8

Physical Society, Colour Group (in the Physics Department, Imperial College, Imperial Institute Road, London, S.W.7), at 3 p.m.—Prof. H. Munro Fox, F.R.S.: "The Nature of Animal Colours"; Dr. M. H. Pirenne: "Colour and Perspective in Painting".

British Psychological Society, Social Psychology Section (at Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Dr. F. E. Emery: "Inducing Technological Change".

Thursday, October 9

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. L. S. Penrose, F.R.S.: "Mutation in Man".*

Physical Society, Optical Group (at Imperial College, London, S.W.7), at 2.30 p.m.—Mr. H. H. Hopkins: "Frequency Response Methods for Assessing Optical Image Quality"; Mr. A. M. Goodbody: "Study of the Influence of Spherical Aberration and Coma on Frequency Response"; Mr. D. Kelsall: "Measurement of Frequency Response Curves in the Presence of Spherical Aberration using an Automatic Recording Instrument".

Physical Society, Low Temperature Group (at the Royal School of Mines, Prince Consort Road, London, S.W.7), at 4 p.m.—Dr. R. T. Webber: "Cryomagnetic Research".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. S. E. Goodall: Inaugural Address as President.

Royal Aeronautical Society (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Mr. J. C. Floyd: "Some Aspects of Canadian All-Weather Fighter Development" (Fourteenth British Commonwealth Lecture).

Society of Instrument Technology, Control Section (at Manson House, Portland Place, London, W.1), at 6 p.m.—Dr. A. E. Cutler: "Aircraft Flight Simulators".

Friday, October 10

British Mycological Society (in the Large Physics Theatre, Birkbeck College, Malet Street, London, W.C.1), at 11 a.m.—Scientific Papers.

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 11 a.m.—Symposium on "Variations in Anatomical Structure and the Causes to Which They are Due".

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Four papers on Astronomical Research.

Physical Society, Acoustics Group (in the Physics Department, Imperial College, South Kensington, London, S.W.7), at 5.30 p.m.—Dr. A. J. King: "Vibration—Its Causes, Measurement and Reduction".

Saturday, October 11

British Psychological Society (in the Gustave Theatre, University College, Gower Street, London, W.C.1), at 2.35 p.m.—Prof. Wolfgang Köhler (Swarthmore College, U.S.A.): "The Present Situation in Psychophysics".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer (with a science degree with special qualifications and postgraduate experience in entomology or helminthology) in Zoology—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (October 10).

Lecturer (Grade III or II) in the Department of Civil Engineering—The Registrar, The University, Bristol 8 (October 13).

Lecturers (2) (with experience of applied electronics or of electrical plant and control systems) in Electrical Engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (October 13).

Demonstrator (primarily zoological) in the Department of Biology—The Registrar, University College of North Staffordshire, Keele, Staffs (October 14).

Readers (2) in Physics—The Registrar, Panjab University, Chandigarh-3, India (October 15).

Vokes Research Fellow in the Department of Mechanical Engineering, to undertake research in the field of filtration, the separation of mixtures, or allied problems in fluid mechanics—The Secretary and Registrar, The University, Southampton (October 18).

Senior Research Officer or Research Officer (qualified zoologist with experience of fisheries research) in the Fisheries Research Unit within the Department of Zoology, University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, October 30).

Lecturer in Geography and Geology at the University of Natal, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, October 31).

Lecturer in Psychology at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, October 31).

Lecturer in the Department of Mechanical Engineering, University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, October 31).

Senior Research Fellows (2), and a Research Electronics Engineer in the Nuclear Physics Research Unit, Department of Physics, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, October 31).

Regius Chair of Materia Medica in the University of Aberdeen—The Private Secretary, Secretary of State for Scotland, St. Andrew's House, Edinburgh 1 (November 10).

Assistant Director of Research in General Surface Chemistry and Colloid Science—Dr. F. B. Kipping, University Chemical Laboratory, Lensfield Road, Cambridge.

Assistant Physicist (with a first- or second-class honours degree in physics) at the Regional Laboratories, Royal Victoria Infirmary, Newcastle-upon-Tyne, for duties relating primarily to the uses of high energy radiation for medical purposes—The Secretary, Newcastle Regional Hospital Board, Newcastle-upon-Tyne 6.

Biochemist (with a degree in biochemistry, chemistry or physiology) in the Pathological Laboratory, Dulwich Hospital- The Group Secretary, Camberwell H.M.C., Dulwich Hospital, London, S.E.22.

Biochemist (with a knowledge of bacteriology) in the Bacteriology Department, for research on the genus *Lactobacillus* and similar organisms—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 58/26.

Engineer or Chemical Engineer, to improve design, and test equipment for extracting and processing leaf protein—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Laboratory Technician (male, experienced in rock sectioning, etc., photography and general laboratory maintenance) in the New Department of Geology—The Secretary, The University, Exeter.

Lecturer (preferably with the ability to teach educational psychology) in Education in the Training Department—The Warden, Goldsmiths' College (University of London), New Cross, London, S.E.14.

Lecturer (with a degree or professional qualifications) in Spectroscopy; and Lecturers (2) in Electronics—The Principal, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3.

Organic Chemists (2), and a Biochemist (with at least a first- or second-class honours degree and special aptitude for exacting preparative chemistry), to work on the labelling of complex compounds with radioactive isotopes—The Personnel Officer (1225Y/34), The Radiochemical Centre, Amersham, Bucks.

Physicist (with considerable experience in radiological protection work), to assist the Superintendent Health Physicist—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 2012/34.

Physiologist (or Pharmacologist) (with a Ph.D. or equivalent experience of research, and preferably experience in pharmacological assay, experimental physiology or electro-physiology) with the Medical Research Council in the Department of the Regius Professor of Medicine, for research into various problems connected with neurohumoral physiology—The Regius Professor of Medicine, Radcliffe Infirmary, Oxford.

Postdoctoral Research Fellow (Biochemist or Chemist), to conduct investigations into the chemistry and biochemistry of carbohydrate sulphate esters—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff.

Regional Technical Information Officer (qualified in pure and applied science with a broad background of knowledge and experience)—The Principal, Welsh College of Advanced Technology, Cathays Park, Cardiff.

Research Assistant (with a degree in physics or a degree in geology and a good knowledge of physics) in Palæomagnetism, for work on the magnetic properties of rocks—The Registrar, The University, Birmingham 15.

Research Assistant (with a good first degree in botany or horticulture, and preferably research experience and a higher degree), for work on the physiology of flowering in carnations—Prof. O. V. S. Heath, Department of Horticulture, The University, Reading.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

A Guide for Industry to the Clean Air Act 1956. Pp. iv+48. (London: Federation of British Industries, 1958.) 4*s*. [307

Library Association. Special Subject List No. 26: Radio Astronomy. Compiled by F. R. Taylor. Pp. 15. (London: Library Association, 1958.) 2*s*. 6*d*. [307

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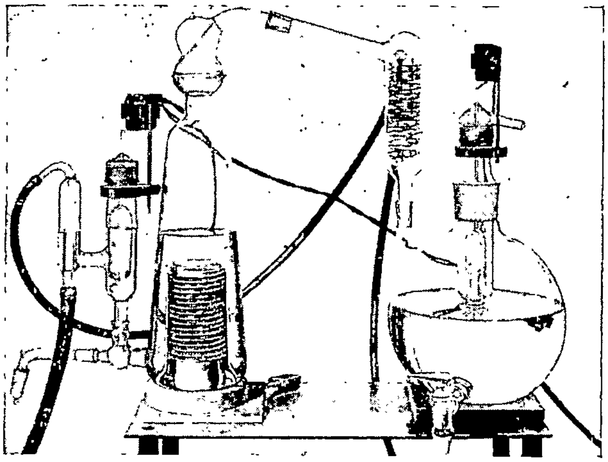

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SPIRITUAL VALUES AND WORLD ORDER

SO far as men of science are concerned, the Lambeth Conference report* follows much the same pattern as its immediate predecessor. The bulk of the report is concerned with topics which are not the immediate concern of scientists, as such, though they will note the resolution which gratefully acknowledges the work of scientists in increasing man's knowledge of the universe. Many, no doubt, will welcome the summons to Christian people which follows "to learn reverently from every new disclosure of truth", as they will, too, the passage in the Encyclical Letter which admits that, "though the scientific and technological achievements of our age have encouraged a spirit of self-confidence which feels no need for God, yet underneath there is a spiritual emptiness"—and some will agree with the concluding words, "which only a faith in the reconciling love of God can satisfy".

This point of view is presented more fully in a passage in the report of the Committee on the Authority and Message of the Bible, in which, recognizing that the conflict which once existed between religion and science, through the misuse on both sides of their respective roles, has largely changed its ground, the Committee holds that a neutrality in which each ignores the other would be disastrous, and affirms its conviction that all knowledge comes from God and is to be reverenced as his gift. In all the discoveries of the sciences, God has a purpose that they may be used to reflect his glory in the world, and the Christian Church is summoned to learn from all new disclosures of truth. In that spirit the scientist should respect the further obligation of the Church to proclaim her message of the righteous God.

This outlook and temper are worth noting, because two sections of the report are concerned with problems with which men of science, as such, are equally concerned, and also because the solution of those problems may well lie, in part, in a harmonious partnership or understanding between the scientist and the Christian Church. First are the problems involved in reconciliation of the conflicts between and within nations, and second are the group of problems centring around the family in contemporary society. On the first, there is a dignified condemnation of racial discrimination in the resolutions and a survey of the racial problem, much of which, such as its condemnation of *apartheid*, is in keeping with representations which scientists, university teachers and administrators and others have made in a particular context, such as the autonomy of the South African universities. There are sensible references to industrialization and to what is required to eliminate industrial conflict and restore a lost sense of community and promote real freedom of communication and its maintenance. There are comments, too, on the rights of men and nations, and the sharing of material resources, which express an attitude of mind freely shared by men of science ; and the concluding section of this Committee's report, in which political conflicts are considered, merits close attention, because it poses a problem of action and of impartiality with which scientists are themselves familiar and which lies at the root of any attempt to apply scientific or technological knowledge impartially and objectively in public affairs.

Outstanding, however, in this field is the problem of peace, and especially the issues raised by the existence of nuclear and thermonuclear weapons. No attempt is made to conceal the existence of a division of opinion in the Conference itself, such as would be found in almost any representative body, Christian or non-Christian, regarding the use of nuclear weapons. The Encyclical Letter admits that while the use of such weapons is repugnant to the Christian conscience, and some regard their use in any circumstances as morally indefensible, others hold that as long as such weapons exist there are circumstances in which to use them might be preferable to political enslavement. The Conference believed that the abolition of nuclear weapons of indiscriminate effect and destructive power by international agreement is an essential step towards the abolition of war itself, and its resolution on modern warfare and Christian responsibility calls upon Christians to press through their governments, as a matter of utmost urgency, for the abolition by international agreement of nuclear bombs and other weapons of similar indiscriminate destructive power, and urges governments to accept such limitations of their own sovereignty as effective control demands.

The resolution further urges the governments of the leading nations of the world to devote their utmost efforts at once to framing a comprehensive international disarmament treaty, which shall also provide for the progressive reduction of armed forces and conventional armaments to the minimum necessary for the maintenance of internal security and the fulfilment of the obligations of States to maintain peace and security in accordance with the Charter of the United Nations. A further resolution, affirming the need for strengthening the United Nations, urges to that end that serious consideration be given to the revision of the Charter, to the more effective use of, and respect for, the existing processes of international justice, and to the creation of adequate means for enforcing its decisions. The resolution likewise commends whole-heartedly the work done under the ægis of the United Nations, whereby the skills and resources of member nations are made available for the benefit of the whole of humanity.

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* The Lambeth Conference 1958. The Encyclical Letter from the Bishops together with the Resolutions and Reports. Pp. 171. (London: S.P.C.K.; Greenwich, Conn.: Seabury Press, 1958.) 7*s*. 6*d*.

This appeal for more enlightened support for the United Nations, so that it may become a more effective instrument of world peace and of that free co-operation between nations which is the condition of world order, is supported by a statement on peace and by a well-argued passage on conflicts between nations in the report of the Committee, over which Archbishop Joost de Blank of Cape Town presided. The statement lays its stress on the price which has to be paid for the establishment of peace and the creation of a world order of freedom and justice on which true peace can be based. It emphasizes that sacrifices will be demanded—of nations and of individuals: the foregoing of policies of self-interest which deny the interests of others, and the acceptance of at least some limitations of national sovereignty. Moreover, it is a long-term process: not in a day can trust replace mistrust, and partnership replace selfishness. Disagreements, rivalries and misunderstanding will long remain between nations and individuals, and a strenuous effort of mind and will is demanded of men if they are to understand and overcome, with a new urgency, the practical problems which divide the human family.

Much of this has been said, with increasing force, over the past thirty years, by scientists themselves as well as by others. The report enters also into the practical details which arise in the reconciliation of a world at so many widely differing stages of development, with such widely varying conceptions of law, freedom and standards of living. None the less, points are made which are worth re-emphasizing, and there is much to support the validity of the Committee's argument in one particular respect of the situation. Accepting the validity of the scientific method in its own domain and recognizing the wide range of benefits which science has brought to mankind, the Committee points out that science itself does not and cannot provide the key to the right use of the immense and rapidly increasing power it has placed in men's hands. The physical power of nuclear fission and the possibilities of psychological or genetic change are as much a threat to man's future life in this world as they are a potential source of great advantage to humanity.

Now that the world has been so progressively conditioned by a scientific climate of opinion as well as profoundly affected by the dazzling material achievements of science and technology, people have come to look upon any knowledge other than that obtained by scientific method as suspect. That is one reason for welcoming this report and the spirit in which it is written. It needs no more than the most cursory review of the achievements—and failures—of the United Nations to reveal how inadequate in international affairs is a scientific approach by itself. Something much more is required than the action that rational inquiry by itself may indicate, and whether or not individual scientists can share the hope of spiritual power in the task which this report might inspire, all men of goodwill should rejoice to welcome any co-operation that promises to assist the long slow task of educating public opinion, the removal of misunderstanding and distrust, and the encouragement of a forward-looking mind and readiness to discard old prejudices and try new ways. There should be a wholehearted response when the Christian Church seeks means whereby it can consult with scientists and political leaders about the many problems of ethics and conscience which may arise from the discovery and development of nuclear fission and fusion.

That in some of these fields scientists do not yet know the answers to the scientific and technical problems should make them the readier to co-operate with all who are open-minded and prepared to face changing situations without prejudice. Moreover, it must be admitted that we cannot even say whether a democratic society can establish and maintain world order. If indeed democracy, as we know it in the West, is to succeed in that task, the high moral and intellectual qualities which it demands of its citizens will require a much more effective system of public education than we have yet known in Britain, and moral and spiritual forces such as, it may be, only a religious faith can supply. To that task of education the Christian Church as well as science may well have decisive elements to contribute; nor need we be too pessimistic, in the perspective of time, if we look back merely far enough to visualize the chaos out of which the modern edifice of science has arisen in the past four centuries.

Already, indeed, the attempt to learn through the mistakes and early experience of both the League of Nations and the United Nations is well under way. When the American Bar Association met in London in July 1957, Mr. Herbert Brownell appealed deliberately for a system of law for the nations of the world, and visualized Anglo-American co-operation in developing the law of the nations so as to bind the countries of the world into solemn voluntary pacts, in contrast to unilateral exploitation by strong Powers. It is not, however, solely among the greater Powers that respect for law has to be fostered and the unilateral repudiation of agreements and contracts discouraged; and even here the existence of widely differing standards of value, of civilization and of ways of thought may at times make progress painfully slow. Nevertheless, it is encouraging to see that over the five years, 1951–56, with a grant from the Ford Foundation, Grenville Clark and Louis B. Sohn, with much assistance and comment from others, have worked out a comprehensive and detailed plan for the revision of the Charter of the United Nations*.

This plan, which has been issued this year by the President and Fellows of Harvard College, under the title "World Peace through World Law", and dedicated "to all those who seek the rule of law in world affairs", aims, therefore, at the promotion of the maintenance of world peace; but its immediate purpose is to contribute material for the world-wide discussions which must precede the establishment of truly effective institutions to prevent war. Its fundamental premise is that there can be no peace without world law, in the sense of law capable of enforcement as distinct from mere exhortation and injunctions, for the enforcement of which there is no effective machinery. It embodies also the conception that peace cannot be ensured by a continuous arms race, or by an indefinite balance of terror or diplomatic manœuvre, but only by the acceptance of institutions corresponding in the world field to those which maintain law and order in local communities and nations.

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* World Peace through World Law. By Grenville Clark and Prof. Louis B. Sohn. Pp. xxxvi+540. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1958.) 7.50 dollars; 60s.

These premises, on which are based a set of definite and interrelated proposals to strengthen the United Nations through the establishment of such legislative, executive and judicial institutions as are necessary to maintain world order under enforceable world law, are reflected in the comments of the Lambeth Conference Committee's report on the reconciliation of conflicts; and, as has already been suggested, the forward outlook which characterizes the report should make it easier for the scientist and the Christian churchman to work together in a task which is as vital to the progress of science as it is to the preservation of mankind. It could not be claimed that the report, or for that matter the plan which Grenville Clark and L. B. Sohn advance, is notably freer from vague thinking than most public discussions of the organization of world order, and some of the premises may be unrealistic and open to challenge. At least, however, the dynamic nature of the situation is clearly grasped, and the report and the recommendations are pervaded by a sense that the solution of our dilemma is not to be found in a stable or static society but in a dynamic position of balance or relative security.

Perhaps even more striking evidence of this open-minded and developing outlook—it is not new, for it occurs in the previous Lambeth Conference report of ten years ago—is to be found in the report of the Conference Committee which dealt with the family in contemporary society. That report, which has been described as the great liberal achievement of the Conference, raises issues other than those of peace and war, of nuclear disarmament, racial reconciliation and the co-operation of Christian and scientist; but it is cited here as conclusive evidence of the growth of common ground over the past decade, and of the extent to which the Christian Church is approaching the problems of the modern world in the spirit characteristic of the scientist in his quest for truth. Even those who cannot accept, at least in its entirety, the thought and conclusions that characterize a Christian assembly may well be glad to recognize the powerful support from such a quarter for policies and causes which they have themselves at heart, and which without spiritual and moral support are ever less and less likely to be attained.

CONTRIBUTIONS TO THE THEORY OF WATER WAVES

Water-Waves

The Mathematical Theory with Applications. By J. J. Stoker. (Pure and Applied Mathematics: a Series of Texts and Monographs, Vol. 4.) Pp. xxviii+567. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 12 dollars.

During and since the Second World War the study of water waves has been pursued with increasing interest both for its own sake and for its numerous applications in oceanography, coastal engineering and ship-building design. Prof. J. J. Stoker and his colleagues at New York University have made many theoretical contributions, and in this book an attempt has been made to combine them into a logical unity.

The first section of the book is introductory; there is a chapter deriving the basic equations for non-viscous, irrotational flow, and the boundary conditions for gravity waves. The conditions at the free surface are non-linear, and the author describes the two standard methods of approximation: the small-amplitude approximation, in which expansions are in powers of the ratio (wave-height/wave-length); and the shallow-water approximation, in which expansions depend upon the parameter (mean depth/l), where l is a typical horizontal length (not necessarily the wave-length). Parts 2 and 3 of the book which follow are devoted to solutions with the small-amplitude approximation and with the shallow-water approximation respectively.

Among the topics discussed in Part 2 are free and forced oscillations in water of uniform depth, waves on sloping beaches of constant gradient, and waves started from rest by a sudden impulse; also the pattern of waves caused by a moving point-pulse in two or three dimensions (the latter being Kelvin's ship-wave pattern). The problem of the diffraction of waves around a vertical wedge is also solved. The assumption of small amplitude for the waves, and of irrotational motion, permits the use of a linearized potential theory. Particularly in the problem of waves on a sloping beach, the author uses complex-variable theory to great advantage. Part 2 ends with a chapter on a linearized theory of ship motion, assuming a thin hull-shape.

Thus far the mathematical treatment is of a high standard of interest, and though experimental evidence is lacking no reader will have difficulty in accepting the conclusions (for waves of sufficiently small amplitude). However, the first chapter of Part 3, which deals with waves in shallow water, is somewhat more controversial. The author applies the method of characteristic curves (also used in gas dynamics) to the propagation of waves in water of constant or slowly changing depth. The theory is approximate and is only valid so long as the vertical acceleration can be neglected. Thus the approximation is scarcely likely to hold for waves near the point of breaking. Indeed, the whole region of validity of this approximation needs further examination. Also included in this chapter are a new treatment of the solitary wave theory, and an application of the shallow-water theory to gravity waves in the atmosphere.

The remaining chapter of Part 3 contains a study of roll waves, assuming an empirical law of turbulent friction. The theory has been applied with some success to flood waves in the Mississippi River.

Finally, in Part 4, the author has grouped together two pieces of work under the heading "problems in which free surface conditions are satisfied exactly". The first of these is a version of Levi-Civita's proof of the existence of permanent waves (of sufficiently small amplitude) in deep water. The proof is slightly shorter than Levi-Civita's, but relies on more sophisticated techniques in function-theory. The other problem treated in this chapter is the flow resulting from a breaking dam (strictly speaking only the initial flow, for the solution is carried only as far as the terms in t^2).

For lack of space, many interesting and important topics have had to be omitted. For example, there is no mention of surface-tension waves, internal waves, or standing waves of finite amplitude, and with the exception of Chapter 11 the interesting effects of viscosity are completely neglected. Other developments, such as the statistical theory of sea waves and the theory of cnoidal waves (which really fills the gap between the small-amplitude theory and the shallow-water theory), are mentioned only in passing. Nevertheless, in those subjects that are discussed more thoroughly the reader will find many useful references.

The book as a whole is written from the point of view of the mathematician; greater attention to the physics (as for example in the case of breaking waves) would have been desirable as well as, more generally, a closer comparison with observation. Nevertheless, Prof. Stoker has produced, if not a classic, yet a book of considerable interest in a rapidly expanding field.

M. S. LONGUET-HIGGINS

ENCYCLOPÆDIA OF PHYSICS

Handbuch der Physik

Herausgegeben von S. Flügge. Band 40: Kernreaktionen I. Pp. vi+553. 128 D.M. Band 42: Kernreaktionen III. Pp. vii+626. 135 D.M. (Berlin: Springer-Verlag, 1957.)

IN Volume 40 a general account of nuclear reactions, levels and spectra by Prof. W. E. Burcham covers the light nuclei up to mass 40, while the same topics are dealt with for heavy nuclei by Dr. B. B. Kinsey. Almost all the experimental work referred to in these two chapters falls into the energy region below 50 MeV. The high-energy region of nuclear reactions is surveyed by Dr. A. Wattenberg, while the basic nucleon–nucleon interactions are treated in their theoretical and experimental aspects in Volume 39 of the series by Drs. L. Hulthen and M. Sugawara. Prof. J. Rainwater has contributed a section on resonance processes by neutrons. The general theory on nuclear reactions by G. Breit and collaborators can be found in Volume 41 (Nuclear Reactions II).

Prof. Burcham writes with his customary lucidity and erudition, about 20 pages of an excellent introduction to the current theories summarizing nucleon–nucleon interactions, models, coupling schemes and the general theoretical features of reactions; this is followed by a chapter on experimental methods for studying energy-levels, always giving just enough theoretical background to produce a happy blend useful to the consultants of this "Handbuch". Dr. Kinsey's contribution comprises a monumental and excellent monograph on nuclear reactions of the more complex nuclei and their levels and spectra. It is well written and, most important, the material is critically surveyed, an onerous task in view of the enormous literature. In view of the discriminating approach it is stimulating; suggestive of ideas and will no doubt be much consulted by research physicists. It is not quite clear to the reviewer why the editor included an article on resonance processes by neutrons, since this subject-matter could have been included in Dr. Kinsey's and Prof. Burcham's article. (See Fig. 33 and Fig. 15 of Dr. Kinsey.) As it is, Dr. Rainwater's section is authoritative, though not too well balanced, dealing almost exclusively with total cross-sections. There are too many graphs of a similar character and three derivations of the Breit–Wigner formula. The last of these could have been left to Volume 41 in "Nuclear Reactions II", where it will presumably be found again in Prof. Breit's article. Dr. Wattenberg's section on high-energy processes is a useful summary for a research physicist working in the field. The article contains a chapter on mesons and their interaction with nuclei, though meson physics proper is dealt with in Volume 43.

The contents of Volume 42 are made up of the following contributions: "Nuclear Isomerism" by Dr. D. E. Alburger (Brookhaven National Laboratory); "Alpha Radioactivity" by Prof. I. Perlman and J. O. Rasmussen (University of California); "The Transuranium Elements" by Dr. E. K. Hyde and Prof. G. T. Seaborg (University of California); "The Nuclear Photoeffect" by Dr. G. R. Bishop (University of Oxford) and R. Wilson (Harvard University); "Angular Correlations" by Prof. S. Devons and L. J. B. Goldfarb (University of Manchester); "Oriented Nuclei" by Dr. R. J. Blin-Stoyle and Dr. M. A. Grace (University of Oxford).

It is a pleasure to be able to say that all the articles in this volume are of the highest standard scientifically and didactically. To have been able to convince the participating authors to undertake such an arduous task confers great merit on to the editor. Who would have been able to cover the two chapters on alpha activity and transuranium elements better than the members of the Berkeley Radiation Laboratory, where so much of the research reported has been done under the inspiring leadership of Prof. G. T. Seaborg. The progress in this field is a spectacular monument to the benefits to science resulting from the development of reactors and accelerators. Forecasting the properties, chemical and physical, from systematics has reached a high state of perfection, and the progress in our ideas on nuclear models stands out clearly, the overwhelming evidence being due to artificially produced nuclei.

Dr. Alburger's article on nuclear isomerism is a model of clear exposition, full of useful information on theory and practice, so that not only the specialist can, in fact, use it. "Angular Correlations," by Prof. Devons and Dr. Goldfarb, covers in a uniform notation all the information one could desire in an excellent monograph (pp. 362–554). The mathematical treatment is, from necessity, abstract, but the results are aptly illustrated by correlation experiments drawn from the literature. This contribution illustrates the degree of theoretical knowledge expected from the experimentalist who embarks on a study of nuclear transition and the character assignment of levels. It is a pity that the teaching in the universities in Britain does not as a rule prepare the student particularly well in a field of such importance. "Oriented Nuclei," by R. J. Blin-Stoyle and M. A. Grace, offers a fine summary of a field where a great deal of important work can still be done. The chapter on the nuclear photoeffect (G. R. Bishop and R. Wilson) presents an able and complete survey of the field covering the experimental methods and the theoretical background for an adequate interpretation of the results. When the physicists have succeeded in producing monochromatic gamma-rays from the presently much-used continuous spectrum we can expect a great deal of further progress. The large intensities of the high-current accelerators hold much hope that this will be done soon.

On the whole, one can say that the field of experiments in nuclear physics and their interpretation in terms of theory have been well covered in Volumes 40 and 42, with the exception of beta decay and the fission process, which are to be found in Volume 41.

The references all through both volumes refer to publications which appeared roughly during 1950–56. Some reports on fields in rapid progress are therefore no longer completely up to date, such as the section on neutron resonance processes, in spite of an appendix. The standard of the "Handbuch" is well up to that of its predecessor published during the years 1926–29 by Julius Springer. It is remarkably free from obvious errors; but there is one misunderstanding: the strength function Γ_n^0/D does not refer to a single resonance but to an average over many resonances (Volume 40, p. 551). The absence of an author index is for some purposes regrettable. The value of this unique encyclopædia to the research physicist and university teacher is very great indeed.

E. Bretscher

ALL THE ENZYMES

Enzymes

By Dr. Malcolm Dixon and Dr. Edwin C. Webb. Pp. xviii+782 (12 plates). (London: Longmans, Green and Co., Ltd.; New York: Academic Press, Inc., 1958.) 90*s*. net.

THIS is one of the finest books that has appeared on the topic of enzymes. It is probably the first to maintain properly the tradition set by J. B. S. Haldane's "Enzymes" of 1930. Dixon and Webb proceed from that definitive treatment of enzymes with adequate mathematical presentation of enzyme kinetics and with concise discussions of properties of enzymes, their isolation, their specificity, their reaction mechanisms, etc., so that both students and research workers can obtain a comprehensive picture of the current status of our knowledge of enzyme action. In these days of 'brainstorming' and 'team' approaches, it is most encouraging to see the excellent and deliberate work of these highly qualified scholars, proving that, in their own terms, "the more old-fashioned type of book has advantages in continuity and consistency of treatment". This volume will surely be the standard reference work on enzymes for a number of years to come and will serve as a point of departure for many monographs on specialized topics in enzymology.

In addition to their extensive integration and categorization of the properties of enzymes, the authors have made a number of attempts to standardize various aspects of enzyme nomenclature and definitions of activities. While not all will agree with some of the classifications of enzymes, coenzymes, and cofactors, the proposals that have been put forward in this volume are logical and adequately documented. Since international commissions are now considering nomenclature and other aspects of enzymology, the material of this book will be extremely useful as a basis for decisions on controversial points, especially since the authors have attempted to maintain an objective point of view on these subjects.

The text is sufficiently extensive (670 pages) to deal comprehensively with the topic of enzymology, but because it is short, irrelevant and trivial aspects have, of necessity been eliminated. It opens with a striking " 'Atlas' of Crystalline Enzymes", which contains microphotographs of available enzyme crystals. In the second chapter, "Enzyme Techniques," the authors state the basic principles of enzymology in a language and form that can easily be understood by the student. This presentation continues through methods of enzyme isolation. Interesting discussions on "criteria of purity" of enzymes and "pitfalls in working with pure enzymes" are given. The book then launches into an extensive chapter on enzyme kinetics which can also be readily understood by the student. The plan of treatment follows that of J. B. S. Haldane and fortunately retains his terminology. Useful equations on the effects of enzyme and substrate concentrations, *p*H, temperature, inhibitors, etc., are included. The reviewer would like to note in passing that this volume may well mark the high-tide in the use of algebra to obtain analytic solutions for equations of enzyme action: analogue and digital computers are advanced to a point where they may be used routinely in further mathematical investigations of enzyme systems.

The fifth chapter contains a magnificent 92-page table in which the enzymes are divided into two main categories: hydrolysing enzymes (221 entries) and transferring enzymes (359 entries). Each enzyme is assigned a number which is referred to uniformly throughout the book. Again, some degree of arbitrariness has been necessary to categorize enzymes in this manner. (It was pointed out to the reviewer that enzyme 173 should be re-located near enzyme 215.) The sixth chapter discusses enzyme specificity and includes detailed data on peptidases and glucose oxidase. The reviewer makes note of the fact that definitive studies of enzyme specificity require measurements over very wide ranges of reaction velocity constants (about 10^6).

In Chapter 7, "Enzyme Mechanisms," a number of current theories on this subject are discussed in detail. However, some of the pages devoted to chain reaction theories might have been better spent on mechanisms for which more experimental data are available. The eighth chapter, "Enzyme Inhibitors," is very complete in its treatment of isolated enzymes. The fact that the book is not intended to cover inhibitors of metabolism leads to an abbreviated treatment of inhibitors in this class. In the ninth chapter, "Enzyme Cofactors," the case for retaining the coenzyme nomenclature (Co-I, etc.) in place of DPNH, etc., is made by the authors. The classification of cytochrome *c* as a carrier and not as an enzyme will be found difficult to apply to a sequence of cytochromes, as in the respiratory chain. Also, the omission of cytochrome *a* from the respiratory chain and the acceptance of evidence for a 'shuttle' and a 'transit time' of cytochrome *c* between cytoplasmic reductases and mitochondrial oxidase may require some reconsideration. The treatment of cytochromes is somewhat below the high standards of the remainder of the book, but this may be caused by doubts in the authors' minds as to the degree to which these enzymes afford a complete explanation of cellular respiration (cf. p. 423). Also, the list of cytochrome oxidases (p. 207) needs some amendment: cytochrome a_1 is not specified and a photo-oxidase of undetermined nature is included.

Chapters 12 and 13 on enzyme systems and enzyme biology, respectively, propose to bridge the gap between the the action of isolated enzyme systems and enzyme functions in the living cell. A 32-page table of enzyme systems represents a useful attempt to achieve an integrated treatment of such systems. As may be expected, the scope of these chapters is somewhat restricted because no serious attempt is made to give a comprehensive review of metabolism as a whole.

The book concludes with a complete list of symbols and abbreviations and a most extensive bibliography, conveniently arranged in alphabetical order and containing 2,353 references. It also contains a detailed and effective index.

This book will be widely used by the student and the research worker; it is easy to understand, easy to use, and authoritative. BRITTON CHANCE

A RECORD "ZOOLOGICAL RECORD"

The Zoological Record, Vol. 92

Being the Records of Zoological Literature relating chiefly to the year 1955. Edited by G. Burder Stratton. Pp. vi+1852. (London: Zoological Society of London, 1958.) 160*s*.

THE present volume relating mainly to zoological literature of 1955 is an indication of the increasing amount of research work in the subject, for this is the largest volume in the history of the "Record". All the sections have now been brought up to date with the exception of Trilobita, which only includes literature for 1954. The delay of about two and a half years in the appearance of the "Record" is surprisingly short in view of the difficulties of publication, and the editors and recorders deserve the thanks of zoologists throughout the world for their invaluable service. It should be emphasized that the individual sections are issued separately as soon as they are ready for publication, so that these are available at a much earlier date than the complete volume. The sections Aves, Comprehensive Zoology and Porifera, for example, were issued in November 1956, less than a year after the literature to which they refer, and most sections were available in 1957.

There is very little change in the relative size of each section, Insecta still heading the list with 535 pages compared with 546 the previous year; then Mammalia, 129 pages, closely followed by Mollusca, Vermes, Protozoa, Arachnida and Aves; and in descending order, Reptilia, Pisces, Crustacea, Amphibia, Trilobita, Coelenterata, Echinoderma, Brachiopoda, Comprehensive Zoology, Protochordata, Bryozoa and Porifera.

A total of 1,963 new generic and subgeneric names is recorded, a drop of 450 on the previous year. It is of interest to compare the numbers in the various groups, which correspond more or less with the size of each section so far as invertebrates are concerned. In the vertebrates, however, Aves, Amphibia and Reptilia with only twelve, four and fifteen new names, respectively, would seem to be reaching a settled nomenclature, but in Mammalia there is the surprisingly high total of fifty-six new names, and in Pisces seventy-one.

The difficulty of inventing new names is well recognized, but the present list in many instances contains such involved and clumsy terminology as to arouse a certain regret that simpler and rather more elegant names could not have been devised.

The "Zoological Record" owed much to the work of Dr. Malcolm Smith, whose death occurred recently. He was sectional recorder of Reptilia and Amphibia for seventeen years and editor from 1938 until 1949, including the very difficult years during the War, when he still managed to maintain the publication of the "Record". EDWARD HINDLE

SYNTHETIC TAXONOMY

The Bladder Campions (*Silene maritima* and *S. vulgaris*)

By E. M. Marsden-Jones and Dr. W. B. Turrill. Pp. vii+378+44 plates. (London: The Ray Society, 1957. Sold by Bernard Quaritch, Ltd.) 30*s*.

THE detailed researches on *Silene maritima* and *S. vulgaris*, begun more than thirty years ago by Dr. Turrill and Mr. Marsden-Jones, are widely known as classics of 'synthetic' taxonomy. Hitherto, the results of these investigations have been available only in a series of thirty-four papers in the *Kew Bulletin*, extending over the years 1928 to 1957, and it has, inevitably, been a matter of considerable time and difficulty to obtain a comprehensive view of the subject. This great volume of work is now brought together, with the addition of previously unpublished data, in a well-illustrated book, a large part of which is occupied by the presentation, in a condensed form, of the evidence on which the general discussion of the last twenty pages is based.

To anyone interested in the wider aspects of taxonomy as revealed by a combination of experimental and 'traditional' methods this book will be invaluable. It shows not only how much can be found out about the history, relationships, ecology, genetics, morphology, anatomy and distribution—in a word the taxonomy—of two common species, but also how much remains to be found out, even after more than thirty years of hard work by two able and experienced investigators.

There remain, of course, large and untouched fields outside the scope of the present study, such as the comparative physiology of the various taxa recognized, but it must be evident to the most casual reader that no plant can be dismissed as common and uninteresting or even ordinary. It speedily becomes obvious on reading this book that any plant can keep a botanist fully occupied for a lifetime and still yield only an approximation to omega taxonomy.

Many years must elapse before knowledge of this kind can be accumulated about all the species of flowering plants, even in such a limited flora as that of the British Isles, but any information about the basis of variation, the kind of breeding-system and the factors which isolate and maintain the distinctness of related taxa has an immediate value to the taxonomist.

It seems, however, that for the foreseeable future we shall have, as the authors point out, to be content with a classification based mainly on the classical criteria of gross morphology, modified in small ways by experimental data. Such a system may indeed prove to be the most convenient all-purpose one in the long run, even should it become possible to make phylogenetic or physiological classifications for special purposes.

T. G. TUTIN

STUDIES IN BUSINESS ORGANIZATION

Business Enterprise

Its Growth and Organization. By Prof. Ronald S. Edwards and Harry Townsend. Pp. xvii+607. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 60*s*. net.

THE authors have produced a book on the growth and organization of business that is at once scholarly and immediately intelligible to the layman; this is no mean achievement. The book is based on a wealth of case material built up over the past twelve years. During that time evening seminars on industrial administration have been held at the London School of Economics, the main feature of each seminar being the discussion of a previously circulated paper written by an industrialist or Civil servant. The incorporation of 'potted' case histories from these papers and elsewhere without making the narrative disjointed has been skilfully done.

The book is divided into four parts dealing respectively with the birth and growth of firms, factors determining the size and specialization of firms, the Government and industry, and the future of industry in Britain. There is a steady and noticeable change of emphasis as one proceeds through the book away from the descriptions, explanations and analyses which dominate Part 1 and towards the exposition of what the authors strongly believe to be good for us, which—necessarily in view of its subject-matter—dominates Part 4. Thus, when we read in Part 3 that, "... the reader should be warned that he is dealing with two authors who believe that every extension of central power should be very amply justified before it is granted, and that the onus of proof should always lie with those who propose centralisation", we are merely receiving confirmation of a suspicion that has been building up over several chapters.

Parts 1 and 2 draw especially heavily on the case material referred to above, which provides numerous examples illustrating the developing theme; each of these Parts has several appendixes comprising papers which have been read to the seminar. Part 3 provides an admirable account of the relations between the Government and industry, and includes excellent chapters on Government organization of industrial research, the location of industry, the steel industry and the organization of nationalized industries.

The dust-jacket tells us that the book is addressed to students of industrial economics and government, and to practising business men. It will be surprising if it does not find favour with a much wider reading public than this. In particular, students of science and technology who intend to go into industry should find it a most worth-while addition to their shelves.

L. G. JAEGER

ARCHÆOLOGY OF SOUTH-EAST ENGLAND

An Archæology of South-East England

By Gordon J. Copley. Pp. 324+28 plates. (London: Phoenix House, Ltd., 1958.) 50*s*. net.

IT is stated on the dust-cover that the information contained in this volume can otherwise be found only in numerous scattered publications, many of them of a specialist nature, and that it is a book unlikely soon to be superseded. With these statements any reviewer must agree. Dr. Copley has studied widely and, so far as the limits of his space allow, has covered the ground of the wide area with which he is concerned. The author of such a work of compilation must of necessity begin by fixing in his mind the sort of public for whom he will be catering. I imagine Dr. Copley has written primarily for the instructed amateur. But the maps and, above all, the gazetteer will be welcomed by the specialist as well.

The work opens with some general chapters dealing with such problems as the amateur in archæology and the natural background. These are followed by chapters on periods—Palæolithic to Middle Ages—and in conclusion there is a study of locality and of place names, a bibliography and a gazetteer. In the period chapters there are distribution maps—necessarily of very small scale—and later in the volume, grouped together, will be found 28 half-tone illustrations. The early chapters depend, to a large extent, on Zeuner's work. He is a good guide, even though everyone does not agree with all he suggests—especially his dating. But for the instructed amateur the opening phases of the book will be found useful. The geo-chronology is, of course, far more complicated than could be dealt with in the short account which space allows, but a generalized picture is given. The Neolithic and Early Metal Age chapters, again within the limits of available space, are excellent. Naturally for the later periods, as so much more evidence has survived, the account has to be more sketchy. But Dr. Copley has managed to see the wood in spite of the trees.

Specialists will welcome the bibliography of local publications. So many local societies publish bulletins nowadays that it becomes difficult even to keep check of their names. In respect of the very valuable gazetteer of sites and finds, one can really only criticize the author for not giving any reference to where the finds were published. He says this could not be done without extending the gazetteer to an inordinate length. But the usefulness of the lists would have been enhanced tenfold if a hieroglyphic had been added to each reference. The hieroglyphics could have been associated with the bibliography. For example, take the "black beauty" from Reculver: palæolithic tools from this place are mentioned by cross-reference under Herne Bay, but no one interested in palæolithic tools from that site can follow up the reference or discover whether they were chance surface finds or the result of systematic excavation and investigation. Should the book run to a second edition it is to be hoped the author will give serious consideration to this very important matter. But it is not on a note of criticism that one wants to conclude. The work is, of its kind, excellent; a wide area is covered, and a good picture given of mankind's existence in the region over a long period of time. The author is to be congratulated.

M. C. BURKITT

Theory of Dielectrics

Dielectric Constant and Dielectric Loss. By Prof. H. Fröhlich. Second edition. (Monographs on the Physics and Chemistry of Materials.) Pp. viii+192. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 30*s.* net.

IT is now about nine years since Prof. Fröhlich's book "Theory of Dielectrics" was first published. It was intended mainly for applied scientists, but was also of great value to those working on the theory of the dielectric constant and its relation to atomic structure. This latter subject (dealt with in Chapter 2) is one which may appear simple, but there is a great deal of confusion and error about it, and we must be grateful that Prof. Fröhlich's exposition is now again available and we can see clearly expressed the relations between the various formulae such as the Kirkwood, Onsager, Clausius-Mosotti, and the conditions under which each is valid. The book also dealt with dynamical problems, and in particular the dependence of dielectric constant on frequency. This is also a very valuable chapter because the Debye equations, for example, are often wrongly used, and the conditions under which they are valid are here clearly stated.

In this second edition the main body of the book has not been changed (though the price has been increased by two-thirds), but three short additional appendixes have been added. The first two are additions to Chapter 2; the third is a brief preliminary account of the work on dielectric loss now being carried out by Sack and Gross.

A. F. DEVONSHIRE

Proceedings of the Second International Congress of Surface Activity

Edited by J. H. Schulman. Vol. 1: Gas/Liquid and Liquid/Liquid Interface. Pp. ix+521. 90*s.* Vol. 2: Solid/Gas Interface. Pp. viii+348. 75*s.* Vol. 3: Electrical Phenomena and Solid/Liquid Interface. Pp. x+621. 100*s.* Vol. 4: Solid/Liquid Interface (Washings, etc.), Cell/Water Interface. Pp. viii+352. 75*s.* (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) Set of 4 volumes, £16; 50 dollars.

THIS Congress was described in *Nature* of August 3, 1957, and the Proceedings have now been published in four volumes with a slightly different arrangement from that suggested in the note on the Congress: Vol. 1 includes gas/liquid and liquid/liquid interface; Vol. 2, solid/gas interface; Vol. 3, electrical phenomena and solid/liquid interface; and the final volume deals with solid/liquid interface (washings, etc.) and cell/water interface. The washings, etc., in the title of the last volume are concerned primarily with laundering and the use of surface-active interfaces in connexion with suspensions of solids and liquids. These four volumes can be bought separately.

The classification has been on a scientific basis, but a very wide range of industrial applications is considered in addition to the main theme of detergency. Thus, froth flotation, lubrication, retardation of the evaporation of water and the many industries dependent on adsorption processes are among the topics considered.

The treatment in the papers of the Proceedings is uneven, as is obvious in the discussions that follow the individual topics treated in the different volumes. It would have been better had a more rigorous selection been made of the papers and particularly if each section could have been preceded by a reporter's summary. Nevertheless, the Proceedings give a most valuable and comprehensive interpretation of modern surface chemistry (and show how much physical chemistry can be included under this heading), with many applications in engineering fields, particularly in the realm of mass transfer.

Numerical Analysis

By Kaiser S. Kunz. Pp. xv+381. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 60*s.*

THIS book is based on notes covering lectures given by the author at the Computation Laboratory of Harvard University during 1947–49. It covers the classical field of numerical analysis—finite differences, interpolation, numerical differentiation and integration, and the solution of equations.

There is an extensive treatment of partial differential equations, and the reviewer is glad to find that the author has presented the subject in proper historical form, due recognition being given to the pioneering paper of 1918 by Liebmann. It seems, for example, that it is not generally known that the approximate solution of Laplace's equation goes back to ideas of Boltzmann and Jacobi. The Liebmann process is compared with the more recently introduced relaxation method of Southwell, and it is pointed out that the latter is far superior for hand computation but loses a good deal of its advantage when used with an electronic computer.

One short chapter is devoted to integral equations, but there is no numerical treatment, the account being confined to the theory of the numerical solution. Most chapters conclude with a set of problems, and this, together with the author's style, not too verbose and not too condensed, will make the book a useful text for students.

L. S. GODDARD

Ptaki Ziem Polskich, Tom I

By Jan Sokolowski. Pp. 441+38 plates. (Warszawa: Państwowe Wydawnictwo Naukowe, 1958.) Cena zl. 80.

SOKOLOWSKI'S work on "The Birds of Poland" was first published in 1936, but the edition was well-nigh destroyed during the Second World War. This circumstance and the post-war alteration of the Polish frontiers has led the venerable author to publish a revised and re-written edition. This first volume of the work deals with the Passeres, Macrochires, Caprimulgi, Upupae, Meropes, Coraciae, Halcyones, Cuculi and Pici that are the residents, migrants and visitors of post-war Poland. The systematics and nomenclature followed are those of G. Niethammer, with a few changes according to G. P. Diemientjew. The text is well illustrated with drawings in black-and-white, coloured plates and photographs, but the low standard of production of some of the plates and most of the photographs is regrettable. The five glossaries in Polish and Latin, Russian, French, English and German are useful, but that in English contains many errors, which is surprising, as the English names in the text are given correctly.

This book is intended for both Nature-lover and ornithologist and gives accurate and penetrating records of biological observations, but there is no orderly, compact and generalized treatment of special topics such as habits, breeding and distribution. The style of writing is fluent, but so wordy and rambling that, unfortunately, it is necessary to search for much of the valuable information the book undoubtedly contains.

B. NOWOSIELSKI-SLEPOWRON

AIR SHOWERS OF SIZE GREATER THAN 10^5 PARTICLES*

(2) ČERENKOV RADIATION ACCOMPANYING THE SHOWERS

By M. H. BRENNAN†, J. MALOS, Dr. D. D. MILLAR and C. S. WALLACE

The F.B.S. Falkiner Nuclear Research and Adolph Basser Computing Laboratories, School of Physics‡,
University of Sydney

In a series of experiments at Harwell and the Pic du Midi, Jelley and his collaborators have demonstrated the feasibility of detecting the Čerenkov pulse associated with an air shower against the background of the night sky luminosity[1-4]. Later experiments by Nesterova and Chudakov[5] have confirmed the results obtained by Jelley and Galbraith. Since the Čerenkov light is emitted throughout the atmosphere, experiments on this phenomenon are of considerable importance since they may lead to a method for investigating the longitudinal development of the air showers.

The early experiments of Jelley and Galbraith were confined to simple apparatus using a light receiver consisting of a parabolic mirror and a single photomultiplier at its focus. Small trays of Geiger counters placed at varying distances from the light receiver were used to detect the arrival of the air showers.

Jelley and Galbraith established that the pulses from the night sky, which were not identifiable as random fluctuations in the photocurrent of the photomultiplier, had an integral pulse-height distribution of the form:

$$R\,(\geqslant H) \propto H^{-1.6 \pm 0.1}$$

They further established that the rate of detecting the pulses in coincidence with a tray of Geiger counters decreased with increasing separation of the light receiver and the counter tray. It was also shown that the observed pulses had properties consistent with their being Čerenkov radiation from the electrons of the air showers. Contributions to the light from bremmstrahlung, recombination light and de-excitation light were found to be at least one hundred times smaller than the contribution from Čerenkov light[4,6].

The experiments which are described in this article were undertaken in order to investigate quantitatively the dependence of the Čerenkov light pulse on shower size and distance of the light receiver from the shower axis. Some preliminary results are also given on the angular distribution of the light. These studies are of particular importance in assessing the results of experiments, using light receivers of the type described by Jelley, to investigate anisotropy in the high-energy cosmic ray flux[3,7]. The article concludes with some comments on the applicability of air shower theory to the interpretation of the observed features of the Čerenkov light associated with air showers.

Experimental Arrangement

The light receiver is located near one end of an array of nine scintillation counters. (A complete description of the array, the method of recording pulse-heights and the method by which the size and location of the core of the shower are determined is given by Brennan, Millar and Wallace[8].) This arrangement enables us to make observations on showers of 10^5–10^7 particles the cores of which fall at distances of 0 to 60 m. from the light receiver.

The light receiver consists of seven photomultipliers with 2-in. diameter photocathodes (*E.M.I.* type 6260) clustered about the focus of a 44-in. diameter parabolic mirror. The focal length of the mirror is 18·6 in. This arrangement results in seven acceptance cones, each of half-angle approximately 3°, the axes of the outer six cones being inclined at angles of approximately 7° to the axis of the central cone, which is directed to the zenith. Tests on the optical properties of the mirror show that for angles less than 7° the circle of confusion is much less than the diameter of each of the photocathodes. For angles of about 10°, just on the outer edge of the acceptance cones, some coma in the radial direction away from the central axis is present. This does not affect the angular resolution of the instrument but may slightly decrease the gain of the outer photomultipliers for sources of small angular size.

The photomultipliers and mirror are housed in a specially constructed hut which has a plate-glass roof. A roller blind cover which is controlled by a time switch opens approximately one hour after sunset and closes one hour before sunrise. This ensures that the light-intensity incident on the photomultipliers is kept within safe limits. The time switch also controls the extra high tension to the photomultipliers.

Pulses from the photomultipliers are fed to individual pre-amplifiers mounted above the photomultipliers. A metal shield is inserted between the circuits to prevent pick-up between channels. The outputs from the pre-amplifiers are fed through coaxial line to the central recording station, where the pulse-heights in coincidence with the air showers detected by the scintillation counter array are recorded on punched paper tape[8].

Extra-high tension to the photomultipliers is supplied from a power supply which automatically adjusts the voltage so that each anode current is kept below 100 μamp. This figure is recommended by the manufacturer as an upper limit consistent with reliable operation of the tube. This procedure enables the detector to operate despite large fluctuations in brightness which occur when low cloud passes over the detector; reflexion from city lights may then cause an increase of a factor one hundred in the light flux incident on the photomultipliers.

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* The first article in this series was published in *Nature* of October 4, p. 905.

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‡ Also supported by the Nuclear Research Foundation within the University of Sydney.

Results from the light receiver are used only when the extra-high tension voltage (which is approximately inversely proportional to the seventh root of the general background intensity) indicates that there is no cloud overhead. This means that, for the events which are analysed, the high tension to the photomultipliers varies from 980 V. to about 1,180 V., which is the limit set by the power supply. These variations in voltage are taken into account by normalizing all pulse-heights to their equivalent value at 1,000 V. high tension. This normalization is carried out from previously determined gain-voltage characteristics of the photomultipliers.

The gains of the photomultipliers were aligned by using the night sky as a diffuse light source and adjusting separate potentiometers supplying high tension to the photomultipliers until the anode currents were the same for all photomultipliers. The gains of the pre-amplifiers were measured *in situ*, so that the overall relative gains of the seven channels were known to about 10 per cent accuracy.

In the present work no attempt is made to make an accurate estimate of the absolute gain of the system in terms of output voltage per incident photon. However, an estimate which is probably accurate to about 30 per cent was made from the manufacturer's figures on gain and photocathode sensitivity. It was found that, for 1,000 V. across the photomultiplier, 1 V. on the coaxial line corresponds to approximately 10,000 photons incident on the photocathode. A pulse is not considered significant in the present work unless it has a normalized height greater than 0·6 V. This rather high threshold is dictated by the high background level of illumination. It is chosen so that, under the worst possible conditions, the chance coincidence rate at the minimum level is only of order 1 in 10^3 events.

Light Pulse as a Function of Shower Size and Core Location

A series of experiments was first carried out with only one of the seven photomultipliers in operation. The central photomultiplier was chosen, and events analysed only when the chart on which the high tension supplied to the photomultiplier was recorded showed that there was no cloud overhead.

A total of 206 showers was recorded for which the above condition was satisfied, and for which shower size and core location could be obtained from the response of the scintillation counter array. Of these events, 22 were accompanied by a pulse from the central Čerenkov photomultiplier of height greater than the minimum acceptable level.

No functional relationship was observed between the size of the Čerenkov pulse and the shower size, N, and the distance, R, of the core of the shower from the light receiver. Indeed, a number of events were obtained in which a large Čerenkov pulse was associated with responses in the scintillation counters too small to permit an estimate to be made of the size of shower and location of core. These pulses may be due to small showers (10^3–10^4 particles) falling very close to the Čerenkov detector or, as will be discussed later, to very large showers striking the ground far from the air shower array but passing through the acceptance cone of the receiver high in the atmosphere.

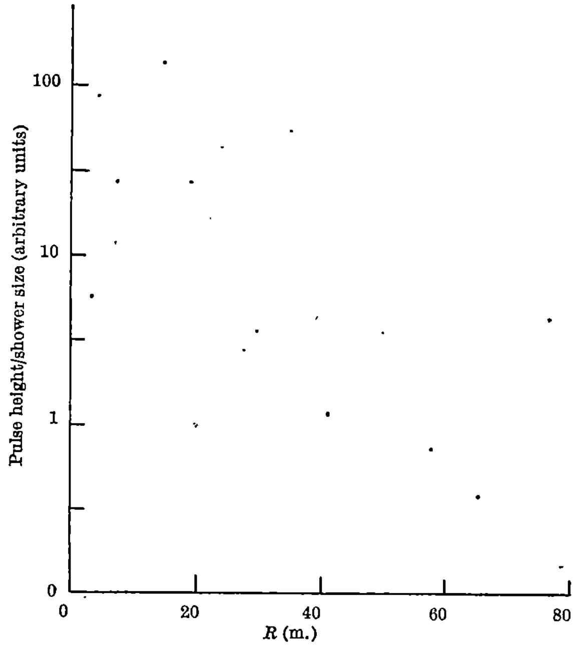

Fig. 1. Dependence of the reduced Čerenkov pulse-height on the distance, R, of the light receiver from the shower core

Fig. 1 shows the ratio, C/N, of Čerenkov pulse-height to shower size as a function of R, the distance of the core of the shower from the light receiver, for the 22 events in which a Čerenkov pulse was recorded. We note that, although there is no functional relationship between C/N and R, the maximum value of this 'reduced pulse height', as we shall call it, is a decreasing function of R.

It is of interest to investigate the fraction of showers detected by the array which were accompanied by Čerenkov pulses of different heights. An analysis of this kind is complicated by the fact that we are forced to reject pulses the heights of which are less than a fixed level (0·6 V.) independently of shower size. Thus, a pulse of, say, 1 V. from a shower of size 10^6 particles is accepted and has a reduced height of $1/10^6$, whereas a pulse of 0·5 V. from a shower of size 10^5 particles is not recorded although it has a reduced pulse-height of $5/10^6$.

In Table 1 are presented the values of the ratio of the number of showers with reduced pulse-heights greater than 10, 20, 40 and 80 (arbitrary units) to the total number of showers recorded by the scintillator array during the time of observation and in the absence of cloud. (We shall refer to such a ratio as a fractional rate.) The showers are classified according to the distance of their cores from the Čerenkov detector. The units used for the reduced pulse-heights are such that a pulse of 10 arbitrary units, associated with a shower of 10^6 particles, is equivalent to approximately 25,000 photons m.$^{-2}$ incident on the light receiver.

In compiling Table 1 we have treated the problem of a fixed minimum acceptable pulse-height by calculating upper and lower limits for the fractional rates. The lower limits are obtained by assuming that all events with normalized pulse-heights not greater than the minimum acceptable level of 0·6 V. have, in fact, zero pulse-height. Upper limits to the

Table 1. Upper and Lower Limits to the Fraction of Showers accompanied by a Čerenkov Pulse as a function of the Distance, R, of the Light Receiver from the Shower Core and as a function of the reduced size of the Čerenkov Pulse

The figures in brackets are the actual numbers of Čerenkov pulses recorded

R (m.)	0–20	20–40	40–60
$C/N \geqslant 10$	0·17–0·28 (9)	0·12–0·38 (12)	0·20–0·30 (1)
$\geqslant 20$	0·11–0·19 (6)	0·10–0·26 (10)	0·02–0·15 (1)
$\geqslant 40$	0·08–0·11 (4)	0·04–0·04 (4)	0·02–0·02 (1)
$\geqslant 80$	0·06–0·06 (3)	0 (0)	0 (0)
Total number of events	53	99	54

fractional rates are obtained by assuming that all such events are accompanied by a Čerenkov pulse of height equal to the minimum level of 0·6 V.

For part of the operating time during which the above-mentioned 206 showers were recorded, one of the off-centre photomultipliers was also in use. The axis of its acceptance cone was inclined at 7° to the vertical and was directed over the centre of the air-shower array. During this time 56 showers were recorded. Of these, 1 was accompanied by a Čerenkov pulse from the central photomultiplier alone, 7 were accompanied by a pulse from the off-centre photomultiplier alone, and 9 were accompanied by simultaneous pulses from both. Results from the 16 off-centre photomultiplier events are presented in Table 2 in a manner similar to those obtained from the central photomultiplier.

Table 2. Fraction of Showers accompanied by a Čerenkov Pulse from the Off-centre Photomultiplier as a Function of the Distance of the Light Receiver from the Shower Core and the reduced size of the Čerenkov Pulse

The method of presentation is similar to that used in Table 1

R (m.)	0–20	20–40
$C/N \geqslant 10$	0·29–0·43 (6)	0·32–0·49 (10)
$\geqslant 20$	0·19–0·29 (4)	0·20–0·34 (7)
$\geqslant 40$	0·19 (4)	0·11 (4)
$\geqslant 80$	0·19 (4)	0·11 (4)
Total number of events	21	35

Despite the rather wide spread between the upper and lower limits to the fractional rates for both photomultipliers, it can be seen from the tables that the probability of detecting a Čerenkov pulse decreases fairly slowly with increasing distance of the light receiver from the shower core (in the range 0–60 m.) and decreases quite rapidly with increasing bias level (in terms of reduced pulse-height). We also note that the average fractional rate for the off-centre photomultiplier (16/56 = 29 per cent) is greater than that for the central photomultiplier (22/206 = 11 per cent). Also, the fractional rate does not decrease as rapidly with increasing bias-level in the case of the off-centre photomultiplier. We shall see later that this may be understood qualitatively in terms of the integrated particle flux in the respective acceptance cones.

Again, for part of the operating time three collinear photomultipliers were in use, resulting in three acceptance cones with coplanar axes, one inclined at 0° and two at 7° to the vertical. Three events were recorded in which all three photomultipliers gave simultaneous pulses.

Angular Spread of the Čerenkov Light

The results presented in the preceding section indicate that the height of the Čerenkov pulse does not bear a simple relation to the shower size, N, and the distance, R, of the light receiver from the shower core. A possible explanation for the occurrence of large fluctuations in the pulse-heights lies in the fact that the air-shower electrons do not all travel in a direction parallel to the shower axis; the Coulomb scattering of the electrons can lead to the emission of Čerenkov radiation from the shower at an angle to the shower axis considerably greater than the angle of emission from a single particle (1·3° at sea-level).

That light is indeed emitted with a large angular spread from individual air showers is indicated by the results presented in the previous section, where it was noted that coincident pulses from two, and even three, photomultipliers looking in different directions were not uncommon. In the case of the three-fold coincidences, the angular spread of the light must be at least 7°.

Further information on the angular distribution of the light was obtained from an analysis of 157 showers for which, in addition to an estimate of the shower size and core location, the direction of incidence of the shower axis was known. This latter information was obtained by a timing technique which has been described briefly elsewhere[9]. As in the investigations on the radial dependence of the Čerenkov light, only the central vertical-looking photomultiplier was used. We may therefore identify the angle of emission of the light (with respect to the shower axis) with the zenith angle of the shower axis (see Fig. 2).

Of the 157 showers analysed, 20 were accompanied by a Čerenkov pulse from the central photomultiplier. The events were first classified into two groups:

Group 1. Showers for which the minimum distance between the axis of the acceptance cone and the axis of the shower occurred above ground; that is, showers which passed 'over' the detector before striking the ground. There were 74 such showers, of which 13 were accompanied by a Čerenkov pulse.

Group 2. Showers for which this minimum distance occurred below ground; that is, showers which struck the ground before reaching the detector. There were 78 of these, of which 7 were accompanied by a Čerenkov pulse.

Within the limits of these statistics, then, a shower crossing over the light receiver is twice as likely to give a Čerenkov pulse greater than our detection limit as is a shower which does not do so. This result would lead one to the view that the size of the light pulse detected is likely to be strongly dependent upon the number of particles traversing the acceptance cone of the mirror.

In order to obtain more detailed information on the angular distribution of the Čerenkov light, we next considered only those events where the skew distance between the shower axis and the axis of the acceptance cone was less than 20 m. Of the 87 showers which satisfied this additional requirement, 10 were accompanied by a Čerenkov pulse. Results for these events are presented in Table 3, in which the fraction of showers accompanied by a Čerenkov pulse is given for several ranges of zenith angle. The method of presenting the results is similar to that used in compiling Tables 1 and 2.

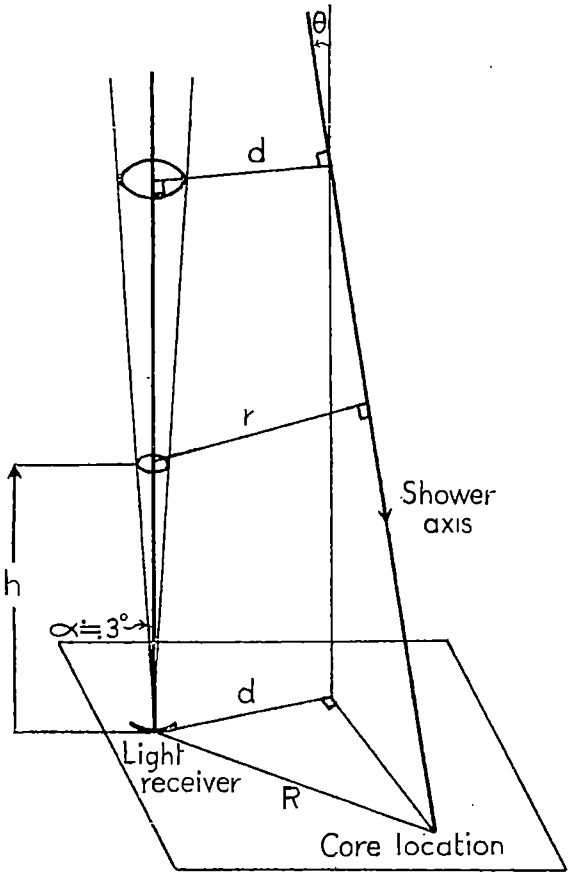

Fig. 2. Schematic diagram of a shower passing 'over' the light receiver

The most significant feature of these results is that the Čerenkov light may be emitted at angles of at least 30° to the shower axis. We thus see that it is not correct to assume that the Čerenkov light is emitted only by particles travelling parallel to the shower axis. As we shall show in the next section, this result is entirely consistent with the theoretically predicted angular distribution of the electrons in a shower. It is also in accord with the numerous photographs of shower electrons in cloud chambers which have been obtained in this laboratory and elsewhere.

The efficacy of the light receiver as a detector possessing a high angular resolution for studies of the anisotropy of air-shower primaries was also investigated, with results shown in Fig. 3. Here are plotted the zenith angle distributions of the 20 showers accompanied by a Čerenkov pulse from the vertical-looking photomultiplier together with the corresponding distribution of all the 157 analysable showers among which the 20 events occurred. It will be seen that for these showers, the cores of which have fallen within a distance of 60 m. from the detector, the requirement that a Čerenkov pulse be recorded has introduced a bias toward vertically incident showers. Half the showers detected by the scintillator array have zenith angles greater than 20°–25°; the corresponding half-angle for the Čerenkov events is 10°. This gain in angular resolution, however, is offset by the accompanying reduction in rate of events recorded.

Table 3. UPPER AND LOWER LIMITS TO THE FRACTION OF SHOWERS ACCOMPANIED BY A ČERENKOV PULSE AS A FUNCTION OF θ, THE ANGLE OF EMISSION RELATIVE TO THE SHOWER AXIS, AND C/N, THE REDUCED SIZE OF THE PULSE

The method of presentation is similar to that used in Table 1

Zenith angle (deg.)	0–10	10–20	20–30	≥ 30
C/N ≥ 10	0·50–0·67 (6)	0·11–0·42 (2)	0·03–0·23 (1)	0·06–0·19 (1)
≥ 20	0·50 (6)	0·05–0·16 (1)	0·03–0·17 (1)	0·06–0·19 (1)
≥ 40	0·17 (2)	0·05 (1)	0·03 (1)	0 (0)
≥ 80	0·08 (1)	0·05 (1)	0·03 (1)	0 (0)
Total number of events	12	19	30	16

It should also be emphasized that this result refers to detected showers the cores of which fall close to the detector. The angular distribution of showers detected using a light receiver alone could be quite different, as discussed further below.

Discussion

The foregoing results indicate quite clearly that the light emitted by the cosmic-ray air shower traversing the atmosphere may be detected at large angles from the shower axis. This fact is not inconsistent with the interpretation that the light is Čerenkov radiation when one considers the angular distribution of the air-shower electrons arising from their Coulomb scattering in the air. Indeed, according to the calculations of Richards and Nordheim[10], the electron angular distribution is expected to be quite broad and for electrons of energy greater than 21 MeV. (the threshold energy for Čerenkov emission in air at normal pressure) the root mean square angle of the electrons relative to the shower axis is 10°.

Although it is not the purpose of the present article to discuss in detail the theoretical interpretation of the Čerenkov light associated with an air shower, it does appear worth while to indicate an approach which should prove useful. For the sake of simplicity we shall ignore the longitudinal develop-

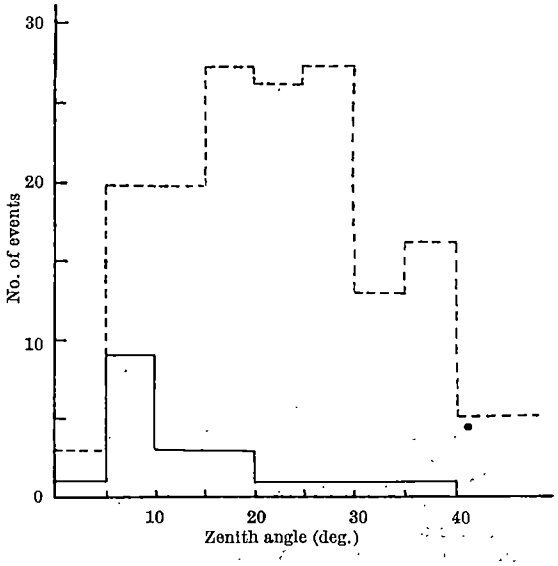

Fig. 3. Zenith angle distributions of 157 showers detected by the scintillator array (dotted line) and of the 20 showers accompanied by a pulse in the vertical-looking light receiver (full line)

ment of the shower. This could be introduced at a later stage when more experimental results are available.

Let us consider the case of a shower of size N, the axis of which is inclined at an angle θ to the axis of the acceptance cone of the receiver. Our notation is as shown in Fig. 2. We first define an average particle density at a particular height h, $\overline{\rho}(h)$. We then define a function $f(\theta,r)d\omega$ which is the fraction of electrons at a distance r from the shower axis which have energies greater than 21 MeV., the threshold for Čerenkov emission at sea-level, and which are travelling at an angle θ to the shower axis in the solid angle $d\omega$.

This angular distribution of the electrons gives rise to an angular distribution, $f'(\theta,r)d\omega$, of the photons. Since the angle of Čerenkov emission (1·3° at sea-level) is much less than the root mean square angle of the electron distribution we may, to a good approximation, replace $f'(\theta,r)$ by $f(\theta,r)$. We may further simplify the problem by replacing $f(\theta,r)$ by $f(\theta,d)$, where d is the skew distance between the shower axis and the axis of the acceptance cone. This appears to be justified since, for the low electron energies considered here, $f(\theta,r)$ will be a slowly varying function of r.

With the above assumptions, the contribution of the electrons at a height h to the number of photons detected by the light receiver is:

$$n(h)dh = k dh\, \overline{\rho}(h)\, f(\theta,d)\, \pi h^2\alpha^2 d\omega = k\overline{\rho}(h)\, f(\theta,d)\, \pi A\alpha^2 dh \text{ photons},$$

where k is the number of photons emitted per particle per unit track length, $d\omega = Ah^{-2}$ is the solid angle presented to the light flux by the mirror of area A and α is the half-angle of the acceptance cone.

If we ignore the variation of k with h, the total number of photons detected will be given by:

$$N = C\int_0^\infty \overline{\rho}(h)\, dh$$

where $C = k\, f(\theta,d)\, A\pi\alpha^2$. That is, the number of photons detected is determined by the integrated particle-density above the detector, and is also determined by the angular distribution of the electrons in the shower.

The experimental results reported in this article are in qualitative agreement with this model. The large fluctuations in the values of C/N as a function of r in Fig. 1 may be ascribed to the fact that the showers detected are not in general vertically incident. The off-centre photomultiplier, which looks out over the scintillator array, detects light pulses in coincidence with air showers detected by the array with greater frequency than does the vertical-looking photomultiplier. The average pulse-height is also greater. Since the majority of showers detected fall with their cores inside the area containing the scintillator array, there is a larger number of shower cores traversing the acceptance cone of the off-centre photomultiplier than is the case for the vertical-looking one.

The distribution of zenith angles of showers the axes of which fall within a skew distance of 20 m. from the axis of the vertical-looking detector is given in Table 3. Knowing the shower structure function, the position where the core has hit the ground and the direction of the shower axis, it is possible to carry out the integration, $\int_0^\infty \overline{\rho}(h)dh$, along the axis of the detector. This has been done approximately for the events of Table 3, and the angular distribution function $f(\theta)$ for the photons, ignoring its possible dependence upon d, has been found to be consistent with the form $f(\theta) \propto \theta^{-0.7}$.

Finally, it is clear from the results shown in Fig. 3 that a vertical-looking light receiver in conjunction with an array detecting air-shower particles will respond to showers falling within a narrower range of zenith angles than would be the case for the detecting array alone. This selection of vertical showers may be produced not only by the forward peaking of the angular distribution of photons about the direction of the shower axis, but also by the larger value of the integrated particle density for a vertical shower.

As pointed out earlier, this selection of near-vertical showers has been shown to apply only to showers the cores of which fall close to the detector. It is quite probable that an air-shower detector consisting of a light receiver alone will respond to showers of quite wide zenith angle distribution, many of the showers detected by it, in fact, traversing the acceptance cone of the receiver at large angles and falling far away from the detector.

Conclusion

From the results reported in this article, it is apparent that in the interpretation of the light pulses associated with the extensive air showers, it is not justifiable to ignore the angular distribution of the air shower particles and the consequent angular distribution of the emitted photons. As a device for the investigation of possible anisotropies in the directions of arrival of the air shower primaries, the Čerenkov detector pointed to the zenith in conjunction with a particle-detecting array will accept showers within an acceptance cone of half-angle appreciably wider than the half-angle of the detector itself. Further investigation is required before one can hope to use the Čerenkov emission from air showers as a means of investigating their longitudinal development.

We wish to acknowledge the facilities made available for this work by Prof. H. Messel and the invaluable support given by the Nuclear Research Foundation. One of us (M. H. B.) has been supported in this work by a grant from General Motors–Holden's, Ltd., and another (C. S. W.) by a grant from the Australian Atomic Energy Commission.

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RADIO AIDS TO NAVIGATION

AT a meeting on September 2 of Section G (Engineering) of the British Association in Glasgow, three papers were read on the subject of "Radio Aids to Navigation". The first of these, by Dr. R. L. Smith-Rose, outlined the general problem and dealt with the principles of the determination of position by the use of radio waves. The other two papers, by Dr. B. G. Pressey and Mr. Caradoc Williams, respectively, described the present state of development of radio aids for marine and aeronautical navigation.

From the earliest days of radio the position of a transmitting station has been determined by the technique of radio direction finding. Using a special aerial system, which may be fixed or rotatable, for receiving waves from a transmitter its direction or bearing may be ascertained. With two or more such direction finders the position of the transmitter is determined by the intersection of the bearing lines. In the first half of the twentieth century various direction-finding systems were developed for use on land, ships and aircraft; and, as a result of much scientific research, the accuracy and scope of such systems have been steadily improved. The application of the technique has been very wide and includes not only navigation but also the location of unidentified transmitters and the sources of thunderstorms. A recent extension has involved the tracking of artificial satellites by the signals emitted by it.

An alternative technique places the directional aerial system at the transmitter, and by suitable coding signals, the bearing of this station can be determined from any receiving point. There are several varieties of such directional beacon transmitters, which are in many ways analogous to the ordinary lighthouse from a navigational point of view. In one type the transmitted signal is directed along a particular route, and switched periodically to either side of this direction. By maintaining a position giving equal received signal strengths, a craft can be navigated along the prescribed course. The Consol system provides a variation on this in that a number of courses are specified by an appropriate coding of the transmitted signals, which change systematically over a period of operation, usually half a minute. An observer using an ordinary receiver, and knowing the approximate direction of the transmitter, can make a precise determination of this direction by merely observing the code signals during the operating period.

The development of radar has resulted in the use of an additional technique involving a measurement of the time of transit of the radio waves between sender and receiver, and so of the distance between these stations. The combination of distance and bearing makes it possible to determine position from a single point without the need for cross-bearings as in normal direction finding.

Among the more recent developments are those which are classified under the title of hyperbolic systems. If synchronized pulses are emitted from two stations they will, in general, be received at different times at a remote station on land, at sea or in the air. Using a cathode-ray tube type of presentation, the received pulses can be displayed on a suitable time base, and their relative times of arrival measured with considerable accuracy. The locus of receiving points at which there is a constant time difference is a hyperbola. Thus the observation of the time difference between the pulses locates the receiver on one of a system of hyperbolæ. If a third transmitting station is included in the chain, a second observation defines the position on one of another system of hyperbolæ, and the point of intersection gives the position of the observer. This is the basic principle of the Gee and Loran systems of navigational aid. Similar networks of hyperbolic loci can be established with continuous wave transmitting stations, as in the Decca system. In this case the hyperbolæ are distinguished by a constant phase difference between the signals received from pairs of stations.

Marine Navigation

From the mariner's point of view, the two principal navigational questions to which he requires an answer are, "Where am I?" and "How far am I from danger?" In conditions of poor visibility these questions can only be answered satisfactorily by radio.

Mention has already been made of the oldest type of radio aid, the direction finder, the main use of which is as a ship-borne instrument operating in conjunction with a world-wide beacon network. Developments during the Second World War have given the mariner three new aids: the long-range directional beacon, hyperbolic position-fixing systems and radar. The first, known as Consol, enables a ship to obtain a bearing with the aid of a normal radio receiver by merely listening to the coded signal. The accuracy of the position obtained in this way depends on the distance of the observer from the beacon; up to a range of 1,000 miles from the beacon, it varies from a few miles to about 20 miles. The principle of operation of the hyperbolic position-fixing system is based on the determination of the difference in the distances of the ship from two fixed points by the measurement of the difference in the times of travel of radio waves transmitted from those points to the ship. Two systems of this type are the Decca Navigator, using continuous waves for medium range operation, and Loran, using pulse transmissions for longer range use. Special measuring equipment is necessary at the receiving end in each case, but this has now been developed to the stage of giving the navigator a direct reading of the co-ordinates of his position. Chains of Decca transmitting stations now cover the whole of the British Isles and a large part of Western European waters; there are also four chains in operation in Eastern Canada. The position-fixing accuracy of the system varies from a few tens of yards in favourable areas to a few miles at night at the nominal 240 nautical mile limit of range from the master station. Loran is essentially a long-range system using pulse-modulated signals radiated from pairs of stations spaced 300–600 miles apart. The service range extends to about 700 miles over sea in the daytime, and because of better propagation conditions, to about 1,500 miles at night. The position-fixing accuracy is high, being about 0·5 per cent of the range, that is, 5 nautical miles at 1,000 miles.

Ship-borne radar enables the mariner to 'see' land and certain types of landmarks up to distances of twenty miles or more and, by measuring the distances to identifiable points, he can easily plot his position on a chart. The more important use of radar, however, is to indicate the presence of other shipping and navigational marks, and so give warning of danger and enable narrow channels to be navigated in thick weather. Shore-based radars are now being used for harbour approach surveillance, information on a ship's position being passed to the pilot by radio telephony or, probably in the near future, by televizing the radar screen. Further developments now under consideration include position fixing systems of very wide coverage and devices to increase the amount of information given by the radar.

Special Problems of Aircraft Navigation

Aeronautical navigation involves the planning and control of the movement of aircraft in position and time along defined tracks so as to reach a prescribed destination in safety. The increasing density of air traffic, particularly in the vicinity of the international airports, creates the need for aircraft to operate in closer proximity and with greater regularity during adverse weather conditions. Radio navigation aids now play a vital part in the safe movement of aircraft; and improved accuracy, greater range of operation, up-to-date information and simplified presentation are the primary requirements. Special problems are present in aeronautical navigation because aircraft move at high speed in three dimensions in a medium of low density. The requirements of aeronautical navigation can be conveniently grouped into three classes: (1) long-range navigation beyond about 250 miles when radio signals propagated by reflexion from the ionosphere may be used; (2) short-range navigation up to about 250 miles when surface wave propagated signals may be used in the metric or centimetric wavebands; (3) very short-range precision navigation such as is required for the guidance of aircraft on to an airfield runway, when metric or centimetric wave-length signals may be used.

The methods of navigation may employ the integration of movement with respect to time relative to a fixed point or the movement may be measured within a fixed co-ordinate framework such as a bearing-distance lattice or a hyperbolic lattice. Dead reckoning is an example of the former process, but the errors in the measurement of airspeed and drift angle have necessitated the development of the Doppler system of radio navigation, which measures accurately the ground speed and drift angle, thus enabling an accurate computation of movement to be provided without the support of radio services from the ground. The facility is of great value for navigation over oceans or in undeveloped parts of the world. Since the process involves the integration of movement with time to ascertain a new position, the accuracy of the result is directly related to the quality of the information used and the integration time. The error in the position of one aircraft is unrelated to the error in position of another aircraft which may be in proximity to it, and under these conditions the measures necessary to prevent collision are obscure. The ideal system of navigation will provide increasing accuracy as the points of danger are approached.

These limitations of the processes employing time integration are the primary reason for the use of systems which lay down a fixed co-ordinate framework in which the aircraft move. If this co-ordinate framework is in use by all aircraft within its coverage, the relative errors in the positions of aircraft are highly correlated and the degree of correlation increases as the craft approach one another.

The simplest form of aeronautical navigation is by use of an airborne direction finder called the automatic radio compass, which provides fixing or homing information with respect to simple low-power non-directional ground beacons or to broadcast stations. By present needs, the aircraft radio compass is a rather inaccurate device because of the small physical size of the loop aerial, and the difficult siting conditions for the loop on the aircraft fuselage. Furthermore, substantial errors can occur at night resulting from signals reflected by the ionosphere which are not plane polarized.

For long-range navigation, low-frequency continuous wave or pulse-modulated signals may be used. These are radiated from widely separated stations which are time interlocked to define a hyperbolic co-ordinate system. Groups of three or more stations form a chain, from which a position can be derived from two or more intersecting hyperbolic position lines. An example of this system is Dectra, which uses continuous wave signals in the 70 kc./s. band to provide track and position along a number of airways which may be 2,000 miles or more in length. It makes use of both ground and ionospheric wave reflected signals depending upon the distance from the stations. The Loran system already referred to has also been widely used for aeronautical purposes.

For short-range navigation, both distance-bearing systems and hyperbolic systems are used. The V.O.R. system provides the means of flying along any radial track by receiving modulated very high frequency signals from a ground beacon which shows the direction of the beacon on a bearing type indicator. A pulse-modulated distance-measuring equipment called D.M.E. can be used in conjunction with it, in which pulse interrogations originating from an aircraft trigger a ground beacon which gives pulse replies, the round trip time being used to indicate distance on the scale of a meter. The problems of the equipment accommodation and the location of the separate aerials in an aircraft necessitated an effort to integrate the bearing and distance services together. This has been achieved in a pulse-modulated system called TACAN, which operates in the 1,000 Mc./s band. As in D.M.E. the pulse signals are initiated in the aircraft and replies are given from a ground beacon which indicates to the pilot the distance of the aircraft from the beacon. The ground-to-air transmissions from the beacon are space modulated to carry bearing information, which is presented on a circular scale bearing indicator, the distance from the beacon being visible in a small window in the indicator dial.

An alternative short-range hyperbolic navigation is provided by the Decca Navigator. By the use of low frequencies of the order of 100 kc./s. and spacing the master and slave stations by 50–100 miles apart, a hyperbolic system of high accuracy is provided. For use in aircraft where instantaneous position indication is required a display is used which shows automatically the movements of the aircraft upon a map.

Some kinds of navigation require great precision over a limited area of coverage, as, for example, the landing of aircraft during bad visibility. These movements create hazards where the points of danger are imminent, and the navigation aids must provide immediate and accurate information. At present, guidance can be given in azimuth and descent by using a precision radar located on the airfield. A ground controller gives a verbal commentary of the approach situation to the pilot on the very high frequency communication channel. He gives the pilot courses to steer, rate of descent and other information during the approach to the airfield until the pilot is within visual distance of the runway.

An alternative form of airfield guidance is by the instrument landing system (I.L.S.), which sets up radio beams to define the lateral and descent path of the aircraft to the airfield runway. The aircraft displacement from the defined track is indicated to the pilot on a meter which has two needles pivoted at right angles. The intersection of the needles with respect to the centre of the dial indicates the correction which the pilot has to make to restore his position on the beam. With large aircraft the practice is being introduced to link these guidance signals to the automatic pilot, so that the descent to the airfield is made under automatic flight control, with the pilot acting as a supervisory monitor to the approach. When he sees the airfield landing lights he takes over full manual control of the aircraft until it is at rest on the runway. The need for complete reliability of the control equipment at this crucial stage is a matter of paramount importance.

MODERN PROBLEMS IN FRICTION AND LUBRICATION

A JOINT meeting of Sections A (Physics) and G (Engineering), under the chairmanship of Prof. J. Small, was held on September 2 at the British Association meeting in Glasgow. In opening the session Dr. F. P. Bowden (University of Cambridge) discussed some problems involved in travelling at speeds of the order of 2,000 m.p.h. The first part of his paper described work in collaboration with Dr. E. Freitag on sliding friction between solid surfaces at these enormous speeds. Elegant experiments using apparatus based on Prof. Beams's magnetic ultracentrifuge had made it possible to study this in the laboratory. At slow speeds of sliding the friction between clean metals is very high, and heavy seizure and surface damage occur. As the speed is increased, however, the friction falls and at sliding speeds of 2,000 m.p.h. it is very low indeed—of the same order as for lubricated surfaces. It would seem that at these speeds the frictional heating which is generated at the sliding interface is sufficient to melt a thin surface layer of the metal; this acts as a lubricant and enables the surfaces to slide easily with low friction and little damage. As a result it may be easier to slide metals over one another at 2,000 m.p.h. than at normal speeds.

Unfortunately not all metals behave in this way. With antimony, for example, surface melting and low friction occur at speeds below 800 m.p.h., but at speeds exceeding this the metal becomes brittle and disintegrates into a fine dust.

The second part of Dr. Bowden's paper described work done in collaboration with Mr. J. H. Brunton on the way in which solids may be damaged if they are hit by rain-drops travelling at speeds of 2,000 m.p.h. A demonstration was given of shooting small cylinders of water (corresponding in volume to a rather large rain-drop) at various surfaces at speeds of this order, the main part of the apparatus being a simple airgun modified to produce the required result. With even the hardest metals the pressures developed at the region of impact are sufficient to produce plastic flow and a saucer-shaped crater is formed in it. With plastics, glasses and ceramics which are strong in compression but weak in tension the behaviour is, however, quite different. The region at the edge of the impact area is subjected to large tensile forces and circular ring cracks are formed. These cracks penetrate beneath the surface and a few successive impacts can cause a large piece of the material to fall out.

Another source of damage which can be even more serious arises from the reflexion of the shock-wave (generated by the impact) in the solid. This travels back as a tensile stress and can detach large fragments of solid from the rear face of the solid. In conclusion Dr. Bowden emphasized that "if we wish to go hurtling around the Earth at a few thousand miles per hour we must learn more about the way in which solids slide, bend and break at very high speeds".

The second contribution, on "Rolling, Skidding and Sliding", was given by Dr. D. Tabor (University of Cambridge). He pointed out that in ordinary sliding the friction was due to two main factors: the shearing of interfacial junctions and the grooving or deformation of the softer surface by asperites on the harder. For most sliding systems the second factor was of minor importance, but there were two situations where it tended to dominate the frictional behaviour. The first was in pure rolling. Even if junctions were formed, the work required to peel the surfaces apart was immensely smaller than the force required to shear these junctions in sliding. The main factor now remaining was the work of deformation, and this could be appreciable even if the surfaces are deformed only elastically. The loss of energy is due to elastic hysteresis in the solids and a demonstration was provided showing that the rolling friction on a rubber of low hysteresis loss was considerably less than on a rubber of high hysteresis loss.

The second situation is observed in pure sliding if the surfaces are so well lubricated that the shearing of the interfacial lubricant film requires only a very small force. In such a case the deformation of the underlying surface may again dominate the frictional behaviour. Thus for hard sliders rubbing on well-lubricated rubber the friction is determined primarily by deformation losses in the rubber itself. A demonstration showed that when rubber slides over a rough, well-lubricated surface the sliding friction is greatly increased if a rubber of low resilience or high hysteresis loss is used. Dr. Tabor concluded by suggesting that a combination of tyre-treads of non-resilient rubber and roadways with a 'knobbly' surface could appreciably reduce the risk of skidding on wet or slippery roadways.

The third paper, on "Lubrication in the Nuclear Age", was given by Dr. C. G. Williams (Shell Research, Ltd.) and dealt with those special mechanisms in nuclear power stations which require lubrication and are exposed to heavy irradiation. Most lubricants deteriorate as a result of irradiation, the deterioration being determined by the energy of the irradiation and not by its type (neutrons, electrons, gamma-rays).

Irradiation energy leads to a break-up of the lubricant molecule with subsequent polymerization and the formation of gumlike or even solid products. Non-petroleum synthetic materials such as silicones do not appear to be very resistant to irradiation; ordinary hydrocarbon oils are somewhat better but the compounds most capable of resisting the harmful effects of irradiation are aromatic hydrocarbons. Apparently the aromatic molecule can absorb energy and then emit it as heat or light without decomposing.

Conventional greases are particularly susceptible to irradiation. They generally consist of a network of soap fibres which encloses the oil globules. Irradiation appears to fragment the fibres so that separation of the oil takes place. A new type of grease has now been evolved in which the soap fibres are replaced by minute clay particles. These particles are strongly attracted to one another and are unaffected by radiation. The grease structure is thus stable, and by using an oil containing a large fraction of aromatic materials a grease is obtained which stands up to irradiation surprisingly well. Dr. Williams's lecture concluded with a short film which illustrated the main themes of his paper.

The fourth paper, by Dr. F. T. Barwell (Mechanical Engineering Research Laboratory (D.S.I.R.), Thorntonhall), dealt with "Newer Aspects of Hydrodynamic Lubrication". He provided a simple direct demonstration of Beauchamp Tower's famous experiment of 1885 which showed that the lubricant between a journal and a bearing developed high hydrostatic pressures capable of supporting the load on the journal. It was this work which led to Osborne Reynolds' classical theory of hydrodynamic lubrication. Although Reynolds' work was of immense importance and had been greatly extended by the use of modern electronic computers there were at least four deficiencies which recent work has revealed. First, Reynolds assumed that the oil film cannot support negative pressures whereas experiments now show that negative pressures in the oil film can exist. Secondly, the oil film is not continuous but breaks up into fibrils in the regions of negative pressure. Thirdly, Reynolds assumed that the viscosity was constant whereas modern work shows that viscous heating reduces the viscosity, while high pressures increase it. Finally, because of thermal effects and elastic flexing of the shaft, bearings run more satisfactorily at high speeds if they are narrower than the classical theory suggests.

Two other problems of current importance arise if the load is not constant in a uniform direction. If the load rotates it can be shown that a critical condition exists when the frequency of the applied load is half that of the shaft. The load-bearing capacity of the bearing becomes vanishingly small and there is very great danger of bearing-failure. The second type of instability which has attracted considerable attention in recent years is that associated with shaft vibration or whirl, and several procedures have been developed for minimizing its more serious features.

Finally, Dr. Barwell referred to the possibility of using air as a hydrodynamic lubricant and demonstrated a commercial electric motor which, with only slight modifications, operated very successfully on air bearings.

The last paper, by Dr. J. F. Archard and W. Hirst (Associated Electrical Industries, Aldermaston), on "The Wear of Metals", was presented by Dr. Archard. The results of many hundreds of wear experiments have led to four relatively simple rules of wear. The first general rule is that at the start of a wear experiment the rate of wear changes as the surface conditions change, but eventually these become stabilized and steady wear conditions obtain. Secondly, under steady conditions the wear rate becomes constant and is roughly independent of the area of the rubbing surfaces. Thirdly, for many materials the steady-state rate of wear is almost proportional to the load. Finally, with metal surfaces there are two main types of wear, 'mild wear' below a critical load and 'severe wear' above it. Under conditions of mild wear, the worn fragments are usually very small, perhaps only a few hundred angstroms across, whereas in severe wear large lumps of metal are torn out of the surfaces.

Although in certain cases a wear fragment may be produced when an asperity on one body shears through the surface layers of the other this is not generally the case. Elegant experiments using radioactive transfer techniques show that in many cases one metal transfers itself as a thin film on to the other as a result of adhesion and shearing of interfacial junctions. The transferred fragments then gradually coalesce and are fatigued by repeated rubbing until they break away from the surface and appear as wear fragments. The exposed surface then becomes covered with a new layer of transferred material and the process continues in this way. The results show that the wear process is often very complex indeed. Finally, Dr. Archard discussed the mechanism of wear in terms of a model involving asperity encounters in which all the encounters contributed to the friction but only a small fraction of the encounters could lead to wear. This model was consistent with the enormous range of wear-rates observed for different materials. Thus although the coefficient of friction for the most diverse solids does not vary by more than a factor of three or four the wear-rates may vary by a factor of more than 100,000. D. Tabor

THE INSTITUTE OF METALS

Although there has been a non-ferrous metallurgical industry in Britain from time immemorial, it was not until 1908 that any organization was available for the general dissemination of knowledge and research in this field. The Iron and Steel Institute had performed such a function for its own branch of metallurgy since 1869, and mining and the extraction of metals, chiefly non-ferrous, were covered by the publications of the Institution of Mining and Metallurgy.

It may well be that the delay in the formation of a body such as the Institute of Metals, which celebrates its golden jubilee this year, was in large measure due to the secrecy which obtained. From the earliest days existing knowledge had been passed on from master to apprentice, and at a later age the guilds had, as part of their functions, to ensure that the apprentice received an adequate training and gave satisfactory proofs of proficiency in his trade before passing on to higher status. It was inevitable in such circumstances that existing knowledge should be restricted to those in the immediate circle, and a similar secrecy existed, though to a diminishing degree, even down to very recent times. Even after the formation of the Institute, successive presidents, year after year, had in the earlier stages of its life to plead for more papers of a 'practical' nature.

It did, therefore, represent a much more liberal outlook when a preliminary meeting, mainly of those concerned in the copper and brass industries, met in Manchester in 1908 to consider the formation of an Institute much on the lines of the existing ones, but for the non-ferrous metals. At a subsequent meeting in London it was resolved that such an Institute, to be called the Institute of Metals, be formed, and the new body held its first meeting in Birmingham in that year.

This Institute has performed many useful functions, but it may be that none of these will ultimately prove to have been of greater industrial value than its general dissemination of experience and new knowledge, not only in Britain but also throughout the world. In its fifty years of life there has been a quite revolutionary change in this respect, and such interchange of information, even between competing organizations, is now the rule rather than the exception. Perhaps there is no more concrete evidence of this fact than the success with which the Institute, largely through its Metallurgical Engineering Committee, has been able to organize symposia, such as those on "Internal Stresses in Metals and Alloys" or "The Metallurgical Aspects of the Hot (and later Cold) Working of Non-Ferrous Metals and Alloys". In those symposia an enormous amount of practical, factual material of the highest importance to industry was published and very frankly discussed.

So far it is the directly practical aspect of the Institute's activities and influence which has been considered, but there is another, and no less important, side to its work. Until its formation, publication of scientific research on the non-ferrous metals was dispersed throughout a wide field of publications. Now, for the first time, a single focus was available in which the vast majority of work done in Britain, and to some extent abroad, was collected. From its very inception the standard of the papers which the Institute has published has been high, and never more so than to-day, and its *Journal* is rightly regarded throughout the world as a scientific publication second to none in the metallurgical field. How much, for example, the development of age-hardening alloys owes to the papers which the Institute of Metals has published cannot, of course, be adequately assessed, but there is no doubt that in this, and in many similar fields, the work which it has published has played an outstanding part.

At one time it was directly concerned with the experimental investigation of corrosion, particularly of condenser tubes, and the success with which this was carried out may be gauged from a testimony of Sir Winston Churchill who, in introducing the Navy estimates for 1940, said: " 'Under the adverse circumstances', to quote a hero's phrase, our ships great and small have been at sea more continually than was ever done or dreamed of in any previous war since the introduction of steam. Their steaming capacity and the trustworthiness of their machinery is marvellous to me, because the last time I was here one always expected a regular stream of lame ducks from the fleets to the dockyards with what was called 'condenseritis', or heated bearings, or other mechanical defects. But now they seem to steam on for ever".

It was realized, however, that the active pursuit of research was not the true function of such an institute, but its single excursion into such a field was highly successful.

To one who, like the present writer, entered metallurgy before the era of the modern—and perhaps he may be allowed to say hypothetical—aspects of metallurgical research were even thought of, it is not easy to assess their ultimate importance in connexion with metallurgical science and technology. When, however, the vast amount of published work which has been coming out from research institutions of all kinds in an ever-increasing flood has been brought together in more concrete terms, a new attitude may well initiate a completely new point of view to producers and users alike, and if this should prove to be the case, those workers whose results have appeared in the Institute's *Journal* and, be it said, all those responsible for the production of this most excellent publication will have played a yeoman part.

It would be quite improper in such a consideration of the Institute's activities to omit mention of the excellent abstracts, which have formed an essential part of its publications from the first. These, in their scope and presentation, are recognized as being inferior to none in the metallurgical or, probably, in any other field.

Another activity of the Institute is represented by its 'May' and 'Autumn' Lectures. The former (generally delivered in March) is a scientific oration not of direct industrial significance but at the same time not without its indirect bearing. The Institute has been particularly fortunate in the men of highest reputation who have accepted its invitation to deliver these lectures. Sir William and Sir Lawrence Bragg, Sir J. J. Thomson, Lord Rutherford, Sir Henry Miers, Sir Willis Jackson are names which come immediately to mind. Through these lectures the members are introduced to fields of knowledge which, though not immediately applicable, may at any time become so. The Autumn Lecture, on the other hand, is concerned with some matter of a more practical nature, often of special importance to the district in which the meeting is held.

In this, as in the case of any similar institute, its growth and influence are directly due to the efforts of those men who work for, and direct the progress of, the organization. A mere list of names of such men would, in the case of the Institute of Metals, be quite formidable, and it is no easy task to pick out even a few whose influence has been of outstanding value. Two of these, however, must clearly be Mr. G. Shaw-Scott, the first full-time secretary of the Institute, who acted in that capacity until his retirement in 1944, and his successor, the present secretary, Lt.-Col. S. C. Guillan. It has been the policy of the Institute from the beginning to choose its president and council in more or less equal numbers from the producer, the user and the scientist, and in all these groups men of the highest attainments have served. The first president of the Institute, Sir William White, had been the director of naval construction and, as consultant to the Cunard Steamship Co., was largely responsible for the construction of the *Mauretania*. Later presidents, such as Sir Gerard Muntz, Prof. Gowland, Sir Henry Oram (engineer-in-chief of the Fleet), Dr. Rosenhain (head of the Metallurgy Department of the National Physical Laboratory), Sir George Beilby, Sir John Dewrance, Dr. Desch, Dr. Seligman, are merely typical of those to whom the Institute owes so deep a debt.

This review has not been able to touch on other important aspects of the Institute's work, its publications, for example, other than those of new research. Among these, the successive editions of Prof. W. Hume-Rothery's contribution to our knowledge of atomic theory as applied to alloy systems are outstanding.

It is not surprising, therefore, that, after a comparatively slow start, the membership of this Institute has grown progressively until it now exceeds five thousand, the members being drawn from every country in the world in which a metallurgical industry exists.

F. C. THOMPSON

DISTRIBUTION OF PROFLAVIN-INDUCED MUTATIONS IN THE GENETIC FINE STRUCTURE

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THE mutagenic action of 5-bromouracil is highly specific, inducing mutations at points differing from those at which spontaneous mutations most frequently occur. This was demonstrated by Benzer and Freese[1] using genetic mapping techniques of high resolution as applied to the r_{II} genetic region of bacteriophage *T*4. Such specificity suggests the possibility of using various mutagenic substances to probe the chemical nature of the genetic fine structure.

We have investigated mutation in the same genetic material induced by proflavin which had been shown by De Mars[2] to be mutagenic in phage. Proflavin is known to interact with deoxyribonucleic acid but, unlike 5-bromouracil, does not appear to become incorporated. Comparison of the distribution of r_{II} mutations induced by proflavin and by 5-bromouracil shows that these two mutagens act on completely different groups of sites in the genetic structure.

Production of Mutants

Proflavin, although not interfering with synthesis of deoxyribonucleic acid in phage-infected cells, inhibits the maturation of phage progeny particles[3,4]. In order to obtain an infective yield, therefore, the proflavin must be removed before the onset of lysis, thereby limiting the time during which it can be allowed to act as a mutagen. In the present work, we have employed a modified technique which in effect permits the separation in time of genetic replication from the maturation process. If chloramphenicol is added ten minutes after infection, protein synthesis is arrested but phage deoxyribonucleic acid replicas continue to be produced[5]. Brenner and Smith[6] have shown that mutations can be induced in the deoxyribonucleic acid formed under these conditions. When the chloramphenicol is removed, mature phage particles begin to form and cell lysis proceeds. We have made use of this finding to maximize the induction of mutation with proflavin.

A stock of *T*4*Br*+ with a low proportion of spontaneous *r* mutants was selected from among several stocks grown from small inocula. This stock contained one *r* plaque among 19,000 plaques examined. *E. coli*, strain *B*, was grown in glucose-salts medium to 2 × 10^8 cells/ml. To 10 ml. of this culture was added proflavin to a final concentration of 4 μgm./ml., and 2 × 10^8 particles of *T*4. After ten minutes of incubation at 37° C., 20 μgm./ml. chloramphenicol was added and incubation continued for one hour. During this period, samples were removed at fifteen-minute intervals, diluted five thousand-fold in glucose–salts medium, titrated for infective centres and incubated for one hour. These experiments showed that during chloramphenicol growth, the infective centres decreased by a factor of four, the average burst size decreased from 200 to 20, and the frequency of *r* mutants among the progeny rose from 0·1 to 0·5 per cent.

Mutants were isolated in two ways:

(1) After one hour in chloramphenicol, the culture was diluted in glucose–salts medium to contain 500 infected cells per ml. and 0·2 ml. dispensed into each of many tubes, which were then incubated for one hour. The contents of each tube were plated on *E. coli B* and 42 independent *r* mutants were isolated, picking one *r* mutant from each tube. The proportion of *r* mutants among the progeny was 0·5 per cent, which represents an increase of about 30-fold over the spontaneous mutation-rate (that is, without proflavin).

(2) After one hour in chloramphenicol, aliquots of the culture were diluted and plated immediately on *E. coli B*. The plaques on these plates arose from infected cells, and the presence of an *r* mutant in the burst from a cell could be noted by the mottled appearance of the plaque. 48 independent *r* mutants were isolated from separate mottled plaques.

In the genetic analysis which follows, there was no apparent difference in the mutants isolated by these two procedures.

Genetic Mapping of the Mutants

The procedure for mapping the proflavin-induced mutations within the r_{II} region of phage *T*4 was the same as that previously described by Benzer and Freese[1]. In brief, the steps were: (1) the r_{II} mutants were chosen by their defective growth in *E. coli*, strain *K*; (2) the mutations were assigned to segments of the region by crossing them with a special set of r_{II} mutants which define these segments; (3) the mutants in a given segment were then crossed

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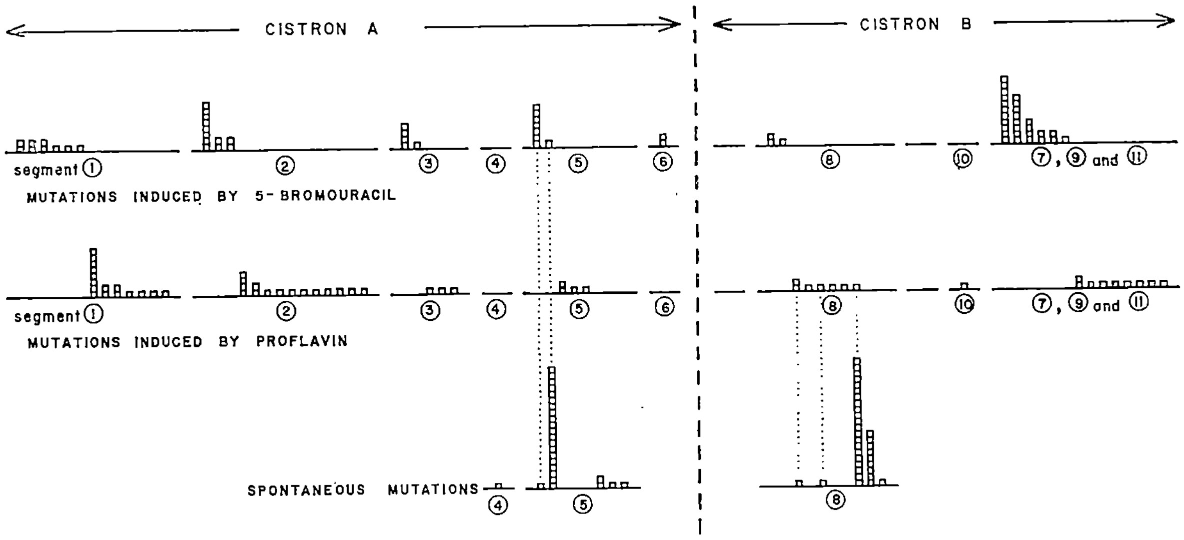

Fig. 1. Genetic maps showing the locations of mutation in the r_{II} region of phage *T4*. Each mutation is represented by a box placed in the proper segment of the map. The relative order of segments 1, 2, 3, 4, 5, 6, 8 and 10 is established, but segments 7, 9 and 11 are lumped together and considered as one segment. Within each segment the mutations are arranged only according to whether they fall at the same or at different sites, without regard to their relative positions in the genetic structure. The comparison of spontaneous mutants with the two sets of induced ones is only given for segments 4, 5, 8. (The overall mutation rate is different in each case. The occurrence at a given location of one mutation in the bromouracil set corresponds to roughly 10^3 times higher mutability at that spot than one occurring in the spontaneous set. In the case of proflavin this factor is of the order of 10^2)

with each other to determine which mutations have different locations. The mutations induced by proflavin were then compared with those induced by 5-bromouracil, by crossing a mutant from each of the proflavin sites in a given segment with one from each 5-bromouracil site in the same segment.

Results

Of the 90 proflavin-induced r mutants, 58 were defective in growth on strain *K*, and were therefore assigned to the r_{II} group. 3 of these r_{II} mutants were not definitely mapped, one had a high reversion-rate and two were complex (possibly double mutants) and require further investigation.

The reversion-rates of proflavin-induced r_{II} mutants are generally quite low. Of the 58 mutants all except two were sufficiently stable that stocks of them contained less than the order of 10^{-6} revertants. In this respect, mutants induced by proflavin resemble those induced by 5-bromouracil. By contrast, many spontaneous mutants have high reversion-rates.

The results of mapping the 55 r_{II} mutants induced by proflavin are shown in Fig. 1. In this map, mutations are indicated as being only at the same or at different sites and the relative locations of mutations within a segment have not been determined. To facilitate the comparison of spectra with the bromouracil spectrum found by Benzer and Freese the sites in each segment have been plotted in order of decreasing mutability for each mutagen.

The comparison of the induced spectra with that of spontaneously arising r_{II} mutants has been made for segments 4, 5 and 8, which contain the major spontaneous 'hot spots'. As is evident from the figure, these sites do not appear as 'hot spots' in either of the induced spectra. Therefore, proflavin like bromouracil does not simply raise the overall mutation-rate but acts at specific, though numerous, sites.

A few of the sites in the induced spectra coincide with the sites of spontaneous mutation. Some of these coincidences can be ascribed to a background of spontaneous mutants to be expected in the induced sets, since the mutagens raised the overall mutation-rate only by a factor of 30 in the case of proflavin and 100 in bromouracil. Other coincidences may represent true increases of mutation-rate produced by the mutagen at a spontaneous site.

A remarkable feature in the comparison of the bromouracil- and proflavin-induced mutation is that each mutagen appears to act on a set of sites quite distinct from the other. Were the spectra similar, about half the mutations induced by proflavin should have occurred at sites already induced in the bromouracil spectrum. The absence of any coincidences is therefore highly significant.

It is interesting also to examine the distribution of recurrences within each spectrum, as shown in Fig. 2. In the case of proflavin, the existence of single occurrences at many sites implies that there remain additional sites at which no occurrence has yet been observed. An estimate of the number of such sites may be made as follows: assuming a set of sites of equal mutability, the number of occurrences at each of these sites should follow a Poisson distribution, so that the number of sites with zero occurrence can be computed from the ratio of the number with two-fold to the number with single occurrences. The data would then indicate that there exist 96 proflavin sites not yet indicated on the map. This is, of course, a minimum estimate, since there may exist as well many additional sites of lower mutability. Clearly, therefore, the proflavin map shown in Fig. 1 is far from exhaustive.

The distribution for bromouracil appears bimodal. There are four spots of very high (and possibly identical) mutability; it is very unlikely that any additional sites of comparable mutability could have failed to be indicated. Even among the less mutable sites, the ratio of two-fold to single occurrences suggests that only a few comparable sites are not yet indicated.

Although the mutagenic effects of proflavin have been studied in many organisms (bacteria[7], yeasts[8],

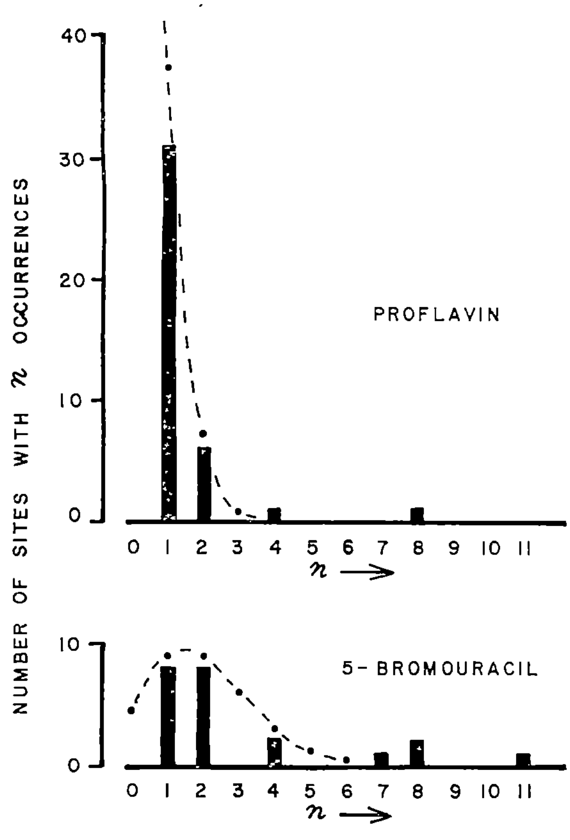

Fig. 2. Distribution of mutation over the various sites induced by proflavin and bromouracil. The dotted line in each case shows the Poisson distribution computed from the ratio of sites with two-fold occurrence to sites with single occurrences

bacteriophage[2] and polio virus[9]) the mechanism of its action is unknown. Unlike bromouracil, proflavin does not appear to be incorporated into deoxyribonucleic acid. Astrachan and Volkin[10] compared bacteriophage deoxyribonucleic acid with that produced in the presence of proflavin. They found some differences between heat-degraded samples, but the significance of this is unclear. Deoxyribonuclease digests, however, were similar, indicating that proflavin did not produce extensive modifications of nucleotide composition or sequences. Proflavin and related acridine dyes are known to form complexes with nucleic acids[11]. Steiner and Beers[12] showed that the combination between polyadenylic acid and acridine orange (the tetramethyl derivative of proflavin) involves interaction between the dye and the adenine ring. The dye does not interact in this way with deoxyribonucleic acid, presumably because adenine is rendered unavailable by hydrogen bonding with thymine nucleotides. Instead, it combines with the phosphate groups[13]. During replication, however, deoxyribonucleic acid may have a configuration in which the nucleotide residues become available to the acridine dye. Such interaction may then be responsible for producing mutations.

The contrast between the three mutational spectra underlines the complexity of the genetic fine structure. A cistron evidently is composed of a large number of mutable elements of several kinds. It should be fascinating to relate these local details to the precise chemical constitution of the genetic structure, but without further knowledge of the chemical mechanisms of mutagenesis this is not yet feasible.

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UTOPIAN EDUCATION

TO commemorate the period when that great nineteenth-century educationist, C. J. Vaughan, was vicar of Doncaster—later he became Master of the Temple and, then, Dean of Llandaff—an annual lecture is delivered in Doncaster Grammar School, which itself owes so much to Vaughan's interest and influence.

The lecturer in 1958 was Prof. W. H. G. Armytage, professor of education in the University of Sheffield, who examined the Utopist tradition in English education*. The name 'Utopians' has been invested with associations of eccentricity and futility. Marx and Engels began the process when they described the Utopians as "fanatical and superstitious" and "pedants", and as "promoters of duodecimo editions of the new Jerusalem". Sidney Webb accused them of having too little faith in human nature, and confessed that they seemed to him to be "throwing up the sponge in despair". Arnold Toynbee allows that "the utmost to which all Utopians aspire is to arrest a downward movement".

The historical Jesus, when talking of the Kingdom of Heaven, gave the Utopians their charter. For, as they read it, the Kingdom was not to be a Church Militant, but a real community bound by love and not by law. Not until the time of Sir Thomas More did the Utopian get his programme. For More's "Utopia" virtually idealized a community. More also brought physical science within the compass of the community.

This was an important accretion to the tradition. Science began to be regarded, and especially by Francis Bacon, as the instrument by which the evil consequent upon the Fall could be expunged. Bacon insisted that material progress could not bring happiness without love, and love was ineffective without power. This power lay through inventions, and, as Bacon looked at history, he saw each invention as a guarantee of truth and the effectiveness of science. Like St. Paul, Bacon believed that philosophy should produce works. He disliked classical philosophy because it committed the sin of trying to conjure the knowledge of Nature out of the mind rather than out of Nature itself.

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* The Utopist Tradition in English Education. By Prof. W. H. G. Armytage. (Sixth Vaughan Memorial Lecture.) Pp. 16. (Doncaster: Doncaster Grammar School, 1958.) 1*s*. 3*d*.

Bacon is a modern prophet. He inspired not only J. V. Andreae's "Reipublicae Christianopolitanae Descriptio" (1619) and the Jesuit Campanella's "Civitas Solis" (1623), but also the founding of the Royal Society in England.

The Utopians were building up a tradition of their own. Andreae had a great influence in England. Among the leaders of a group which worked to establish a *societas christiana* were Samuel Hartlib, John Dury and John Amos Comenius. They believed that it was the essential preliminary of the Christian society that a system of universal schools should come into operation to teach all men all things. Hartlib worked to establish a university in London in which there should be taught the scientific principles of trades, like glass-working and metallurgy. Comenius, unfortunately, could not go ahead with his scheme for establishing a college at Chelsea. But the idea persisted, in the Royal Society, and comes down to us virtually undimmed in intensity. Perhaps its best twentieth-century exponent was H. G. Wells, who acted as an evangelist for science.

Much of modern Utopist thought can be discovered in the literary genre known as science fiction. There is another and more important aspect of Utopist endeavour which is almost entirely forgotten. This is the story of those who tried to form communities. The Quakers are pre-eminently communitarian in their approach to religion and education. It was a quartet of Quakers who backed the second great English Utopian, Robert Owen, when he purchased his father-in-law's factory in 1813 to carry out his experiment on the formation of character at New Lanark. The established Church took umbrage at the environmentalist nature of his creed. There was, however, one member of the Established Church who believed in Owen's idea of the regenerative power of community life. This was John Minter Morgan, who is a good embodiment of the Utopist mentality. He was a philanthropist with a private income, and in 1826 he published a book called "The Revolt of the Bees". It was the story of a hive that went through five revolutions, from "noble savagery", through "pastoral occupations", "farming" and "industry", to a fifth revolution pioneered by "the wise bee" (Owen). After this fifth revolution all benefited from a redistribution of the fruits of wealth and knowledge. The "practical and durable form" was for communities to be built surrounded by parks and gardens, to house 1,000 families. The interesting point about Morgan's suggestion was that those who did not live in communities would be able to use the churches as community centres. He envisaged the churches being open on work-days and evenings for lectures and general community activities. This plan was put into operation in Sheffield two years ago with the establishment of St. Mary's Community Centre at Bramall Lane. Morgan, like Owen, envisaged education as the instrument whereby the general level of the population could be raised. In 1833 he urged the authorities of the newly founded University of London to establish a chair of education; this is the first direct proposal for such a chair in England.

In the 1840's Morgan formed a group to secure the establishment of what he called a self-supporting village, but which to-day would be called a satellite town. Among his supporters were the Rev. Francis Close at Cheltenham, the Vice-Chancellor of Oxford, and William F. Cowper.

Another convert was a former member of parliament for Sheffield, James Silk Buckingham. Buckingham spoke most warmly on behalf of Morgan's scheme for an experimental community, and suggested that one might be started at Hounslow Heath or Salisbury Plain. Buckingham came out three years later with his own proposal for a community. This proposal was the first concrete and complete plan for a garden city; it contains a number of uncanny prognoses of future developments. The centre of the town was to be a large green park with the main public buildings grouped around it. Houses were to be in broad avenues in square belts around the civic centre. Workers' dwellings were to be in houses on the outside frontage of the town, near the green belt. A liberal intermixture of open spaces and parks was suggested to relieve the drabness of these. Houses were to be graded according to the size of the families and their economic circumstances. Children were to stay at school until they were fifteen years of age; medical service was to be free, with doctors paid by the community to prevent disease. Civic restaurants were to be established to feed the inhabitants. It was Buckingham's plan which inspired Ebenezer Howard, founder of the Garden Cities Association.

In spite of hostile reception, the Garden Cities Association was formed in 1899. This Association was responsible for the establishment of the first garden city at Letchworth in 1903. The Garden Cities Association helped in the development of garden suburbs at Hampstead, Warrington, Hull, Bristol, Cardiff, Manchester, Rosyth, Liverpool, Ruislip, Bolton, Rochdale and Woodlands, near Doncaster.

The climate of opinion which nourished the Garden Cities Association also produced the Fellowship of the New Life, an informal group founded in Chelsea in 1882 by Thomas Davidson; members of the society were required to lead a higher life. It was a difference of opinion over the formation of a community in England which led some of the Fellowship to separate from the parent body and form the Fabian Society. The secretary of the Fellowship was Ramsay MacDonald, and its main activities were promoting not so much experimental communities as experimental schools. The first Fellowship school was founded at Abbotsholme in Staffordshire. "All schools," insisted the Fellowship's journal, *Seedtime*, "ought to be communities, miniature commonwealth or states, as they were in the Middle Ages. How otherwise can they impart the preparation necessary for adult life?" It was a secession from Abbotsholme that led to the foundation of the second experimental school, Bedales, near Haywards Heath. The third school which sprang from the Fellowship and the Garden Cities Association was St. Christopher School, Letchworth. Just as Abbotsholme threw off Bedales, so St. Christopher School threw off Frensham Heights School at Farnham in Surrey. Both St. Christopher School and Frensham Heights aimed at affording the fullest possible community life of work and play. Another outpost of Letchworth was the Mansfield House Settlement in London.

The Utopists, laughed at and despised in their day and age, have not been without their effect on history. Bacon was the real father of the Royal Society, the Owenite socialists were the fathers of the garden city movement, and the Fellowship of the New Life incubated a number of experimental schools.

To-day the community planners have a real relevance. This is an age of community centres, satellite towns, group dynamics, sociometry. One of the major intellectual attractions is the rediscovery of a community of Essenes. Another is the current preoccupation in psychology and psychiatry with what is called group therapy. Sociologists, too, are affected: Pitirim Sorokin has established at Harvard a Research Centre in Social Altruism. The Christian Church itself has acquired an enhanced awareness of the importance of community relationships. Utopian literature is well known; what is not so well known are the literary by-products of Utopist endeavour. One is "The Pilgrim's Progress" and another is "The Vicar of Wakefield".

OBITUARY

Dr. G. R. Bisby

Guy Richard Bisby, plant pathologist and mycologist, who died at his home in Staines, Middlesex, on September 3, was born at Brookings, South Dakota, on August 17, 1889. He came of farming stock, and like many of his contemporaries worked his way through the university, graduating B.S. from South Dakota State College, 1912, and becoming an M.A. of Columbia University, 1917. In the following year he was awarded the degree of Ph.D. by the University of Minnesota for a thesis on *Fusarium* diseases of potato. During 1916–20 he was instructor, then assistant professor in plant pathology in the University of Minnesota, and later, until 1936, professor of plant pathology and plant pathologist in the Manitoba Agricultural College, Winnipeg (where he took Canadian nationality). He spent 1921–22 in England at the Imperial Bureau of Mycology, and in 1937 returned to the Imperial (now Commonwealth) Mycological Institute, Kew, where he became senior assistant mycologist—a post he held until his retirement in 1954.

The author of more than a hundred books and papers on plant pathology and mycology, Dr. Bisby is best remembered as a taxonomist. His strength in this field was an ability to make up his mind, and this, combined with a systematic approach and prodigious industry, gave him the knack of bringing to a conclusion any project on which he might engage. In a notable series of collaborations he set the pace and brought to fruition catalogues of the fungi of Manitoba, India and Ceylon, lists of the Pyrenomycetes, Hyphomycetes and rusts of Great Britain, and a "Dictionary of the Fungi".

He was interested in many different groups of fungi, and although he will be perhaps particularly remembered for his studies on the Hysteriales, he made important contributions to our knowledge of the Hyphomycetes, especially *Stachybotrys* and *Trichoderma*. He was in charge of the rust collections at the Commonwealth Mycological Institute, and his ready help in identifying specimens and his prompt replies to inquiries will be remembered with gratitude by many overseas plant pathologists. One result of Dr. Bisby's interests in nomenclature was the most useful little book, "The Taxonomy and Nomenclature of Fungi", 1945 (2nd edition, 1953).

Of a retiring disposition, Bisby was seen at his best talking 'shop' in his room at the Institute or in his garden (which was as well-ordered and as weed-free as his taxonomy); but he had many interests, including chess, archæology, the clarinet and, like many taxonomists, stamp collecting. One of his chief hobbies, due in part to a wide circle of friends in North America, was correspondence, and many mycologists welcomed the sight of his clear handwriting and the signature written with such dash and flourish.

Dr. Bisby received a number of honours. He was vice-president of the British Mycological Society, a member emeritus of the American Phytopathological Society, and in 1956 the University of Minnesota awarded him the gold medal for outstanding achievements.

G. C. Ainsworth

NEWS and VIEWS

The Woodrow Wilson National Fellowship Foundation

Sir Hugh Taylor, dean emeritus of the Graduate School of Princeton University, has been appointed first president of the Woodrow Wilson National Fellowship Foundation. Dr. Hans Rosenhaupt, assistant provost of Columbia University, has been appointed national director of the Foundation. The headquarters of the Foundation are at 32 Nassau Street, Princeton, New Jersey.

The Woodrow Wilson National Fellowship Foundation was founded in 1957 with the main objective of recruiting outstanding students for careers as college teachers. In 1957, after the Wilson Fellowships had been jointly underwritten for five years by thirty-seven American universities and by grants from the Carnegie Corporation and General Education Board, the present programme began with a grant of 24,500,000 dollars from the Ford Foundation for a five-year period. During the first year of its operation the Foundation granted fellowships to nearly a thousand students in the United States and Canada who will graduate this year.

H. W. M. Olbers

Heinrich Wilhelm Matthias Olbers, who was born at Arbergen, a village on the Weser near Bremen, two centuries ago on October 11, 1758, was an amateur astronomer who, even after his discoveries had been accepted and acclaimed, continued his medical practice. The son of a minister, he studied mathematics and medicine at the University of Göttingen, where he graduated M.D. in 1780 with a thesis entitled "De oculi mutationibus internis". While still a student, he devised the first satisfactory method of calculating the orbit of a comet in 1779.

His "Abhandlungen über die leichteste und bequemste Methode die Bahn eines Kometen zu berechnen", with a table of eighty-seven calculated orbits, which was made public by Baron F. X. von Zach in 1797, won him universal fame. A second edition was issued in 1847 and a third in 1864. Olbers took up medical practice at Bremen in 1781, but devoted the greater part of each night to astronomy, having fitted the upper portion of his house as an observatory. On January 1, 1802, he rediscovered Ceres, the first minor planet discovered by Giuseppe Piazzi in 1801, and on March 28 observed the second asteroid Pallas, followed by Vesta in 1807. His theory that these planetoids are fragments of a quondam planet, disrupted by internal explosion or by the impact of a comet, was sanctioned by William Herschel, but is no longer accepted. In 1815, Olbers discovered a new comet which bears his name and which has a period of 74 years. He showed that the tail of a comet consists of a filmy vapour driven off from the head by a repulsive force in the Sun, which is now known to be the pressure of solar radiation. He retired from medical practice on January 1, 1823, and in 1830, the jubilee of his graduation, he received an honorary doctorate from the medical faculties of Berlin, Bonn and Copenhagen. He died on March 2, 1840, in his eighty-second year.

World Data Centre for Rockets and Satellites, Slough

A World Data Centre for Rockets and Satellites is now operating at the Radio Research Station of the Department of Scientific and Industrial Research at Ditton Park, Slough, Bucks. This is the third of three centres established under the International Geophysical Year arrangements for centralization of this type of information. Previously there have been rocket and satellite data centres only in Moscow and Washington, and it was agreed at the recent Moscow meeting of the Special Committee for the International Geophysical Year to accept a British offer of a third rocket and satellite centre. The Radio Research Station is an appropriate place for such centres because many satellite experiments are concerned with studies of the ionosphere. Studying the travel of radio waves from satellite transmitters is one way of gaining information about the ionosphere. Research workers at the Radio Research Station and its Singapore sub-station are engaged in such work. Data from the British investigations will be collected by the Slough Data Centre and exchanged with the other data centres in the United States and the U.S.S.R. Information on International Geophysical Year rocket flights and the published reports of investigations will also be collected. All data will be available for inspection and use by workers in the respective scientific subjects under arrangements which apply to all world data centres.

Reorganization of the Admiralty Material Departments

The First Lord of the Admiralty announced in the House of Lords on December 19, 1957, a reorganization of the Material Departments under the Controller of the Navy, following upon the report of Sir Barclay Nihill's Committee. The reorganization was completed on October 1 when the new Ship Department was set up. The work of the Controller's departments will then have been reorganized into four large material departments (concerned, respectively, with ships, weapons, aircraft, dockyards and maintenance), each headed by a director-general, and a small group of scientific departments headed by the Chief of the Royal Naval Scientific Service, who will work under the immediate guidance of the Deputy Controller (Research and Development). This group is broadly responsible for basic research and development, the provision of scientific staff and advice to the material departments, and the planning and co-ordination of Admiralty research programmes. Applied research and development will continue to be carried out at the various scientific establishments. The superintendents of those establishments, which will form a part of the supporting services of the new Ship Department, will be responsible for the work of their respective establishments to the Director General, Ships, through the directors of the appropriate professional divisions. The senior scientific officer serving in the Department will act as chief scientific adviser to the Director General and to the directors of Divisions.

B.B.C. Television

An interesting addition to the publications of the British Broadcasting Corporation is a booklet entitled "B.B.C. Television—a British Engineering Achievement" (pp. 64. London: B.B.C., 1958. 2*s.* 6*d.*). This is a very well produced and copiously illustrated review of the development and present attainments of the Corporation's television service. Reference is made to the early experimental transmissions begun in 1929, and to the report of the Postmaster-General's Television Committee issued in January 1935, which was followed by the opening of the first public television service in the world during the succeeding year. A brief outline of the principles of television is followed by an up-to-date picture of the television facilities which have been built up and are now in use by the B.B.C., with a full description of the new Television Centre now under construction near Shepherd's Bush. A map in colour showing how B.B.C. television broadcasts reach more than 98 per cent of the population, and advice on how to get the best reception of the B.B.C. television service are other items in this booklet. The effects of various forms of interference are also described and illustrated. A mobile television control room is illustrated together with the various methods of telerecording, including the most recent 'vision electronic recording apparatus' (VERA) which will shortly be put into general service. Outside broadcasts account for approximately one-sixth of the B.B.C.'s television programme output. Apart from dealing with activities in Britain, an account of the growth of the international exchange of television programmes known as Eurovision, which was pioneered by the B.B.C. and Radio Diffusion Télévision Française, is supplemented by a map showing the Eurovision network.

Electronics, Radio and Telecommunications

Considerable progress is being made in the publication of English translations of Russian scientific and technical literature. Three journals have recently become available published in English translation on the initiative of the Massachusetts Institute of Technology and the Pergamon Institute, assisted by a grant-in-aid from the United States National Science Foundation. One of these is *Telecommunications* (No. 1, 1957. Pp. 1–94. First English issue. Issued in parts, approximately 1,000 pages per annum. Annual subscriptions: to individuals, 15 dollars

(107*s*.) ; to libraries, research laboratories, Government departments and industrial organizations, 30 dollars (214*s*.). New York and London : Pergamon Press, 1958). The first issue contains a number of articles on various aspects of radio and line telegraph and telephone matters. It also includes a brief review of the characteristics of U.S.S.R. State television standard for black-and-white television broadcasting on a 625-line system.

The other two journals appear to be longer established. *Radio Engineering and Electronics* (2, No. 2, 1957. English edition. Pp. 1–183. Approximately 2,500 pages per annum. Annual subscriptions : to individuals, 22.50 dollars (160*s*.) ; to libraries, research laboratories, Government departments and industrial organizations, 45 dollars (320*s*.). New York and London : Pergamon Press, 1958) contains fourteen articles related to various subjects in electronics, including wave-guides, dielectrics and cathode-ray tubes. A brief article on the life and work of Heinrich Hertz, in relation to the centenary of his birth (February 22, 1857), is also included. *Radio Engineering* (12, No. 8, 1957. First English issue. Pp. 1–112. Approximately 2,500 pages per annum. Annual subscriptions : to individuals, 22.50 dollars (160*s*.) ; to libraries, research laboratories, Government departments and industrial organizations, 45 dollars (320*s*.). New York and London : Pergamon Press, 1958) is devoted to technical and theoretical aspects of the subject of its title, and is the official publication of the A. S. Popov Technical Society of Radio Engineering and Telecommunications.

Coryndon Memorial Museum, Nairobi

It is pleasing to note that the annual report for 1957 of the Coryndon Memorial Museum at Nairobi makes no reference to any restrictions on its work by Mau Mau activities (pp. 28+1 plate. 1958. Nairobi : Museums Trustees of Kenya and the Coryndon Memorial Museum). Instead, the whole energy of the staff has been turned to constructive measures, and several new exhibits have been prepared. The Bongo habitat group has been enlarged and new groups depicting Abbot's Duiker and Klipspringer installed. Exhibits dealing with the bats of East Africa, melanism and albinism proved popular. Additional marine and freshwater fish were shown in the aquaria, the most outstanding being a young shark and several species of dragon fish. In the Gandhi Hall the mineral and rock exhibits were augmented, many new geological maps were displayed and a new exhibit dealing with recent discoveries at Olduvai Gorge was placed on view. Stamps and postal literature have now been included in the collections.

Forestry in Ulster

An illustrated pamphlet, "Forestry in Northern Ireland" (pp. 20. Belfast : Ministry of Agriculture, 1958), which includes a map of these forests, issued by the Ministry of Agriculture, Northern Ireland, appears to be admirably designed to serve its purpose as a piece of public relations policy. It sets forth clearly and concisely the origin and development of the State forests, the purpose they serve and the policy pursued in their management. At the same time, it indicates their need of public understanding and support, as well as the nature of that support and the contribution to public amenity and enjoyment which the forest parks now offer. A regulation made under the Forestry Act (Northern Ireland), 1953, declared Tollymore Park, near Newcastle, County Down, open to the public as a forest park, and the Park, which covers about 1,200 acres, was officially opened on June 2, 1955.

Careers in the Plastics Industry

Under the title "Careers in Plastics" (pp. 20. London : The Plastics Institute, London, 1958), the Plastics Institute has issued, for the guidance of senior scholars and those responsible for advising them on the choice of a career, a pamphlet setting forth the opportunities presented by the rapidly growing plastics industry, particularly for those with technical qualifications or scientific training. Besides a summary of the technical appointments available, the pamphlet includes information on the constitution of the industry, and particulars of how to enter it, and the technological, professional and academic qualifications desirable (with a chart indicating the various routes by which they may be obtained) and details of teaching centres where approved courses for the qualifications of the Plastics Institute can be pursued. Some indication is given of salaries and prospects, and there is a short appendix on the pupil apprenticeship scheme for the industry, which shows incidentally how well placed a professional body is to press for the adjustment of apprenticeship conditions to meet modern needs.

The National Institute for Research in Dairying

Research workers in many branches of science, practical farmers and agricultural advisory officers will all find something of interest and importance in the annual report of the National Institute for Research in Dairying for 1957 (pp. 160. Shinfield : National Institute for Research in Dairying, University of Reading, 1958. 4*s*.). It is largely devoted to a concise account of the research work done in each of the various departments and sections of which the Institute is composed, while for those who do not require to have so much detail a brief outline is given of many of the recent research findings. The subjects dealt with in the brief outline range from such immediately practical problems as labour-saving devices in feeding lactating sows and grazing management of lactating cows, to basic work such as that on the utilization of amino-acids by the isolated perfused bovine udder and the deoxyribonucleic acid content and histology of the mammary gland. Mention of work done by the Statistical Section on the derivation of general orthogonal polynomials helps to illustrate the breadth of the Institute's programme of work, and in this atomic age perhaps it is not surprising to find that the problem of salvaging milk which has been contaminated with radiostrontium has already been studied. The report gives a detailed list of 151 papers most of which were published in 1957.

The Marshall Pulse Height Analyser *HS* 100

The Marshall pulse height analyser has been developed at the Airport Works of Marshall of Cambridge under licence from the National Research Development Corporation, with the object of producing a first-class British instrument exhibiting all the characteristics of existing analysers at a fraction of the cost but retaining their accuracy and achieving the utmost reliability. This is effected by the use of the Hutchinson–Scarrott principle, using computer techniques for the storage of information performed in serial manner using two torsional acoustic delay lines. This system is inherently simpler in construction and less extravagant in components than the core memory type of analyser. The facilities include a visual display and automatic read-outs in both analogue and digital systems. The analyser will accept a wide range of pulses of either sign up to a maximum mean counting rate of 1,600 pulses per second. The input pulses may be back-biased at the input to the amplifier, when a gate is provided for coincidence and anti-coincidence work. The memory is divided into either 100 or 150 channels, for which the energy scale may be either linear or exponential, the latter case giving greater resolution at the lower energy end of a spectrum. Another extremely useful facility is the ability of the instrument to subtract counts from a spectrum already in the memory. In conjunction with the live-time integrator, which is necessary at a high counting rate, the background count can automatically be subtracted from a spectrum, leaving the true count in the memory. A total count scaler records the total number of pulses analysed by the instrument. Further information concerning this analyser can be obtained from Messrs. Marshall, The Airport, Cambridge, England.

International Measurements Conference

An International Measurements Conference organized by Hungarian, Polish and Soviet scientific societies is to be held in Budapest during November 24–30. Plenary sessions are to be concerned with papers on the more fundamental matters of units and standards of measurement, together with techniques of measurement and instruments in their broadest aspects. Section meetings are to discuss papers on instruments and measuring methods for: mechanical quantities and precision mechanics; light and colour; temperature, flow, humidity and other process parameters; electrical and magnetic quantities; electronics; physico-chemical quantities; X-rays and nuclear radiations. Papers on economic, organizational and educational aspects of industrial instrumentation comprise a third group. The Proceedings are to be published. During the conference the Hungarian Industrial and Scientific Instruments Exhibition will be open to participants. Further details are obtainable from the Secretariat, Budapest 5, Post Office Box 3.

University News: Birmingham

The following appointments have been made: Dr. Janet S. D. Graham, lecturer in botany; D. P. Howson, lecturer in electrical engineering; B. D. Richardson, lecturer in civil engineering; Sir Francis G. W. Knowles, Bart., and A. W. Rogers, lecturers in anatomy; H. A. Ellis and D. J. Parish, lecturers in pathology; J. D. Cumming, lecturer in physiology.

London

Dr. W. O. James, reader in botany in the University of Oxford, has been appointed University professor of botany and head of the Department in the Imperial College of Science and Technology (see *Nature* of October 4, 1958, p. 916). Mr. H. Charnock, principal scientific officer in the Royal Naval Scientific Service, has been appointed to the readership in physical oceanography tenable at the Imperial College of Science and Technology. Dr. Karl Wilson, lecturer in botany in Birkbeck College, has been appointed to the readership in botany tenable at the College. The title of Henry Mark Pease (Standard) professor of telecommunications in the University of London has been conferred on Dr. E. C. Cherry in respect of his post at the Imperial College of Science and Technology.

Announcements

Sir Rudolph Peters, professor emeritus of biochemistry in the University of Oxford, and lately director of the Agricultural Research Council's Institute of Animal Physiology, Cambridge, has been appointed president of the International Council of Scientific Unions in succession to Dr. Lloyd Berkner.

The Niels Bohr Gold Medal, awarded for outstanding achievement in the field of peaceful uses of atomic energy, was presented to Sir John Cockcroft in Copenhagen on October 7.

Vice-Admiral Sir Frank Mason, formerly Engineer-in-Chief of the Fleet, has been appointed a member of the Council for Scientific and Industrial Research.

Dr. J. G. Malloch, representing Canada, has been appointed chairman of the Executive Council of the Commonwealth Agricultural Bureaux in succession to Mr. T. Swaminathan, who represented India. Mr. A. Perera, representing Ceylon, has succeeded Dr. Malloch as vice-chairman.

Dr. Lewis E. Lloyd, associate professor of nutrition in the Macdonald College of the McGill University, has been awarded the Underwood Fellowship by the Agricultural Research Council, to continue his studies of the metabolism of rumen micro-organisms. For the greater part of the year, Dr. Lloyd will work at the Rowett Research Institute, Aberdeen.

The seventh Coal Science Lecture of the British Coal Utilization Research Association will be given by Sir Charles Goodeve at the Institution of Civil Engineers on October 15. It will be entitled "Carbon: the Key to Metallurgy". Further information can be obtained from the Association at Randalls Road, Leatherhead, Surrey.

A series of lectures by leading experts on space research and technology is being organized by the University of Maryland. The lectures will be held on Monday evenings during October 13–December 1. Further information can be obtained from the Director of Institutes, University of Maryland College of Special and Continuation Studies, College Park, Maryland.

The Journées Métallurgiques d'Automne of the Société Française de Métallurgie will be held in Paris during October 20–25. Further information can be obtained from the Société at 25 Rue de Clichy, Paris 9^{e}.

The next award of the Meldola Medal, which is the gift of the Society of Maccabæans, will be made early in 1959 to the chemist who, being a British subject and less than thirty years of age on December 31, 1958, shows the most promise as indicated by his or her published chemical work brought to the notice of the Council of the Royal Institute of Chemistry, 30 Russell Square, London, W.C.1, before December 31, 1958. Letters of application or recommendation should be accompanied by six copies of a short statement on the candidate's career (date of birth, education and experience, degrees and other qualifications, special awards, etc., with dates) and of a list of titles, with references, of papers or other works published by the candidate, independently or jointly, preferably with one reprint of each published paper of which copies are available.

SCIENTISTS IN THE PUBLIC SERVICE IN BRITAIN

SPECIAL PROMOTIONS

FURTHER special posts have been created in the Civil Service under provisions included in the White Paper on the Scientific Civil Service (Cmd. 6679; 1945) to provide for the promotion of individual research workers of exceptional merit. The promotions, which are effective from July 1, include the following:

Chief Scientific Officer

DR. N. P. ALLEN has been superintendent of the Metallurgy Division at the National Physical Laboratory, Teddington (Department of Scientific and Industrial Research) since 1944. He was a lecturer in the University of Birmingham, where he obtained the degree of D.Sc. in 1934. As a research metallurgist with the Mond Nickel Co., Ltd., he made important contributions to the study of alloy steels and to the development of creep-resistant alloys for gas turbines. At the National Physical Laboratory he has been responsible for work on the metallography of uranium, the brittle fracture of exceptionally pure iron and the influence of additions on it, the development of improved materials for steam power plant and the processes taking place during the fatigue and creep of metals. He has been interested in the metallography of the newer metals such as titanium and niobium, and in the application of radioactive tracers, electron microscopy and soft X-ray spectroscopy to metallurgical problems. He was elected Fellow of the Royal Society in 1956.

Deputy Chief Scientific Officers

DR. I. J. GOOD joined the Government Communications Headquarters in 1941, leaving in 1945 to lecture in mathematics in the University of Manchester. He returned to the Government Communications Headquarters in 1948, and has made notable original contributions to statistical theory and the development of advanced methods of application to Service problems.

MR. H. L. GREEN joined the Physics Section of the Chemical Defence Experimental Establishment in 1922. In January 1949 he was given special promotion on individual merit to the grade of senior principal scientific officer. He has been engaged, and is a recognized authority, on problems related to particulate clouds and filtration, developing many novel devices and techniques for sampling and assessing aerosols and conducting research which has led directly to widely used filter systems including those in respirators. Of late years, he has also been working on problems of radiological defence, including the physics of nuclear fall-out. He has served on Committees of the Department of Scientific and Industrial Research, the Home Office and Medical Research Council and (with W. R. Lane) is author of a recent book, "Particulate Clouds: Dust, Smokes, and Mists".

MR. A. R. HOWELL joined the Royal Aircraft Establishment in 1938. He was a research engineer with Power Jets (Research and Development), Ltd., during 1944–46. On the conversion of the firm he joined the National Gas Turbine Establishment, and since 1949 has been, as a senior principal scientific officer, head of the Aerodynamics Department. Mr. Howell's career has been devoted mainly to the aerodynamics and performance of gas turbines and he is well known for the analysis on which the design rules for the modern axial compressor are based. He has made original contributions on ejectors, theory of aerofoils in cascades, flutter of compressor blades and engine-assisted lift. He is a Fellow of the Royal Aeronautical Society.

DR. J. G. NAGELSCHMIDT, who joined the Safety in Mines Research Establishment in 1949, is a mineralogist of international reputation and is now engaged on research on the mineralogical aspects of pneumoconiosis. He has made important contributions to the study of the toxicity of dusts, as well as in the metallurgical and chemical fields, where he is both an expert and an authority. He has been a pioneer in the application of X-ray diffraction techniques to the study of clay materials, in the application of new mineralogical techniques to the study of dusts responsible for lung disease, and in the application of the electron microscope to the study of clay minerals and dusts. He has developed new techniques for the quantitative mineralogical analysis of small dust samples and for the identification of mineral particles too small for identification with the optical microscope. He is secretary of the Medical Research Council's Sub-Committee on Dust which co-ordinates pneumoconiosis research in Britain; he is a member of the Council's Industrial Pulmonary Diseases Committee, and of its working party on atmospheric pollution. He is also a member of the committee of the Clay Minerals Group of the Mineralogical Society.

MR. J. S. SAWYER, assistant director (dynamical research), joined the Meteorological Office in 1937. He joined the new Forecasting Research Division at Dunstable in 1948, becoming assistant director in 1953. In the past ten years he has made major contributions to the study of rainfall, depressions, the tropopause and the dynamics of fronts, as well as to the revolutionary subject of dynamical forecasting by the numerical integration, using electronic computing aids, of sets of differential equations derived from basic fluid dynamics and thermodynamics. Developments in this promising field are likely to be the main concern of his group for some years to come.

DR. W. S. STILES's original work at the National Physical Laboratory was concerned with problems of vision arising in illuminating engineering, and he did valuable work on glare from car headlights and on street lighting. From these applied problems, he was led to a series of basic studies of the threshold sensitivity of vision under a wide range of stimulus conditions. One outstanding result was the resolution of several mechanisms concerned in colour vision, by methods independent of the traditional colour-matching approach. Dr. Stiles is probably best known as the discoverer, with his colleague, Dr. B. H. Crawford, of the directional sensitivity of the retina—the Stiles–Crawford effect. Dr. Stiles's investigations during the Second World War of such Service problems as visibility and visual scanning methods was recognized by his appointment in 1946 as O.B.E. Since then he has resumed his investigations of vision, and his latest contribution to the subject is a large-scale determination of average colour-matching properties. In 1957 he was elected Fellow of the Royal Society for his work on vision.

MR. C. K. THORNHILL, joining the Government service in 1939, worked successively at the Projectile Development Establishment, the Ordnance Board and the Armament Research and Development Establishment. In 1952 he was given special promotion on individual merit to senior principal scientific officer. Mr. Thornhill is a versatile applied mathematician. His early research was on the development and lethality of rockets, external and internal ballistics, gun-heating and gun-erosion, and led to the award of the U.S. Medal of Freedom for meritorious service in the Second World War. More recently, he has contributed to several fields of weapons research and has become a recognized authority on steady and unsteady gas dynamics and on explosion phenomena, working particularly of late on the effects of atomic explosions. Mr. Thornhill served on the Compressible Flow Tables Panel of the Aeronautical Research Council, and contributed portions of its well-known published collection of tables and graphs.

MR. R. A. WELLS is in charge of the Radiochemistry Group at the National Chemical Laboratory of the Department of Scientific and Industrial Research. He has played a large part in the foundation of analytical techniques based on chromatography and applied to inorganic materials, now used in Australia, South Africa, Rhodesia, Portugal and Canada. These researches constitute an outstanding achievement in analytical procedures during the past decade. He also devised field techniques for the determination of various metals in river waters. In hydrometallurgical research he has developed new methods for the concentration and extraction of metals, for example thorium, by the use of modified celluloses such as the phosphorylated product; and a series of selective ion-exchange resins whereby gold can be recovered from cyanide liquors. He has on occasions acted as a consultant to the Atomic Energy Authority on flow-sheets and costing in connexion with full-scale industrial uranium-extraction plants.

Senior Principal Scientific Officers

MR. P. J. E. FORSYTH, of the Metallurgy Department, Royal Aircraft Establishment, is a skilled experimenter who has done outstanding work on fundamental aspects of the fatigue of metals and alloys.

DR. L. GRUNBERG is engaged in the Lubrication Division at the Mechanical Engineering Research Laboratory of the Department of Scientific and Industrial Research on the chemical and physico-chemical aspects of lubrication in relation to the wear of the rubbing surfaces of machine components. He is distinguished for his work on the study of the emission of charged particles occurring on freshly deformed metal surfaces.

DR. F. E. JONES is a member of the Chemistry Division at the Building Research Station of the Department of Scientific and Industrial Research, where he has worked on the chemistry of cement and concrete, and in particular on the products formed on hydration; and on the corrosion of metals under the particular conditions that arise in buildings.

DR. D. MCK. KERSLAKE, of the R.A.F. Institute of Aviation Medicine, is in charge of the Climatir Research Laboratory. His work in recent years hac been mainly directed towards the protection of air-crews against extremes of cabin temperature, and in this particular field he has become well known throughout Britain.

DR. T. S. MOSS, of the Radio Department, Royal Aircraft Establishment, has carried out much original experimental and theoretical work on the properties of semi-conductors and is a leading authority on photo-conductivity and infra-red detection.

DR. C. A. PARKER is head of the general chemistry division at the Admiralty Materials Laboratory, which includes in its programme radiochemistry, X-ray techniques and ferrite chemistry. He is now specializing in photo-chemistry.

MR. H. H. B. M. THOMAS, of the Aerodynamics Department, Royal Aircraft Establishment, is well known as an authority on the stability and control problems of aircraft.

MR. P. R. WALLIS, working at the Admiralty Signal and Research Establishment, has been responsible for much of the development of radar techniques for guided weapon systems.

DR. JOHANNA WEBER, of the Aerodynamics Department, Royal Aircraft Establishment, has worked on a variety of problems in classical theoretical aerodynamics, including the theory of lifting surfaces in supersonic flow and the minimization of wave drag.

DR. J. G. WHITMAN, of the Mechanical Engineering Experimental Establishment, has a wide background of engineering research, especially in problems of welding and of the fatigue and failure of metals and metal structures.

Similar promotions have been made by the Agricultural Research Council, as follows:

Deputy Chief Scientific Officer

DR. ROBERT BROWN, after graduating with first-class honours at the Imperial College of Science and Technology, London, in 1936, held various teaching appointments. He was a senior lecturer in botany at the University of Leeds during 1946–49, when he became reader in plant physiology. He joined the staff of the Agricultural Research Council in 1953 on his appointment to the directorship of their Unit of Plant Cell Physiology at Oxford. Dr. Brown's researches are principally directed to the cellular phenomena involved in plant growth and differentiation. He has given particular attention to the meristems, analysing development in terms oy cell division and cell expansion. In October 1958 Dr. Brown will become head of the Cell Biology Department of the John Innes Horticultural

Institution. Dr. Brown was elected Fellow of the Royal Society in 1956.

Senior Principal Scientific Officers

Dr. H. F. **Barnes** is deputy head of the Entomology Department at Rothamsted Experimental Station. He is a world authority on gall midges and he has published widely on these and other insect pests.

Dr. K. L. **Blaxter**, head of the Nutrition Department of the Hannah Dairy Research Institute, has been particularly concerned with research on problems related to the energy exchange of large farm animals.

Dr. G. A. **Levvy** is head of the Enzymology Department of the Rowett Research Institute. He is working in the field of the biochemistry of the glycosidases of their inhibition by aldonolactones.

One similar promotion to senior principal scientific officer has been made by the Atomic Energy Authority. Dr. P. E. **Cavanagh**, who is head of the beta-ray spectrometer group at Harwell, doing mainly basic research but also responsible for some technical developments, including that of the recording of nuclear-pulse data on magnetic tape. Achievements in basic research include the original observation of the double Compton effect—a higher order process in quantum electrodynamics—and the first accurate measurements of electron polarization violating parity.

The Development Commission has similarly promoted Dr. H. **Barnes** to senior principal scientific officer. Dr. Barnes has been a research chemist on the staff of the Marine Station, Millport, since 1946, and is well known for his work on physical and chemical oceanography. In addition, he has developed underwater television apparatus and is an authority on the biology of barnacles.

OCCUPATIONAL PSYCHOLOGY

AMONG the best-attended meetings in Section J (Psychology) of the British Association this year were those held during the occupational psychology session on September 1. Four papers were given in the course of the morning on which the session was held. Anyone looking for continuity or what the papers had in common might have remarked that the first dealt with competitive entry into industry in youth—trade apprentice selection—while the last dealt with retirement—largely compulsory retirement—from industry because of age. From another point of view there was also a certain similarity between the first three papers. All were, in a sense, directly concerned with problems of inspection; the first, 'inspection' of suitability for trade-apprenticeships in shipbuilding; the second, routine inspection of industrial products; and the third, systems of fault-finding in electronic equipment.

In the first paper, by Mr. J. G. McComisky (University of Hull) and Dr. P. P. Daws (University of Edinburgh), the introduction and development of an apprentice selection scheme in a Glasgow shipyard were described. In 1956, when the firm approached the Applied Psychology Unit of the University of Edinburgh for assistance, only about half the boys put on the firm's pre-apprentice trade courses were reaching the necessary standards to become indentured. In round figures, to obtain its quota of about 80 trade apprentices each year, the firm was obliged to put about twice this number through its pre-apprentice courses. All boys entered on courses were regarded as being likely to succeed. Following a review of the position when the firm asked for assistance, the following programme was decided on: (1) That immediate steps be taken to check the effectiveness of the firm's own system of initial selection. This consisted of an arithmetic test and an interview by the firm's apprentice supervisor. The arithmetic test was checked and found to be faulty. It was discarded and a new arithmetic test introduced. (2) That a selection scheme involving psychological testing be run for an experimental period of one year, and if the results warranted it, that this should replace the firm's existing system of selection. (3) That the selection scheme be developed in a way which would enable the firm's apprentice supervisor to run it with the need for no more than occasional advice and guidance from a psychologist.

Before experimental selection began, all second-year trade apprentices in the firm were given the battery of psychological tests which it was proposed to use during the experimental phase of the scheme, the object being to see what relation there was between scores on the various tests and foremen's assessments of the second-year apprentices. A meeting was also arranged with the instructors on the pre-apprentice courses, the object being to enlist the co-operation of these in the projected scheme right from the beginning, and also to obtain information on the kinds of difficulties met by both instructors and boys on the pre-apprentice courses.

With the information and insights obtained from these sources experimental selection began. This, in practice, entailed giving all the boys on the firm's courses the battery of tests decided on, interviewing each for about 15 minutes, and then predicting whether or not the particular boy was likely to pass the course. An attempt was also made to spot particularly bright boys, as the firm was anxious to put these in line as early as possible for technical advancement in the firm. The degree of success in predicting failures and bright boys in the experimental year was encouraging enough to justify the procedure being put into effect as the official apprentice selection scheme of the firm.

In the first year of actual selection wastage on the courses dropped considerably: on the shipbuilding side—one of the two main divisions of the firm's apprenticeship system—it dropped from 42 to 22 per cent with a reduction of 33 per cent in the number of boys entered on courses. On the marine engineering side, the smaller division of the firm's apprenticeship system, the results were not as good, but the failure-rate in the first year of real selection dropped to

41 from 55 per cent in the previous year with the prospect of being further reduced. Work on improving the scheme is continuing. Dr. Daws, who has been supervising it for the past two years, has just discovered, for example, from his analysis of the relationship between scores on the tests and ability on the pre-apprentice courses, that the combined score of the five most effective tests in the battery—a verbal and a non-verbal intelligence test, a test in spatial ability, one in mechanical comprehension and one in arithmetic-mathematics—forms a most effective predictor when used alone. The refinement and adoption of this predictor will considerably simplify the selection procedure as a whole.

Since the full introduction of the scheme eighteen months ago it has been run by the firm's apprentice supervisor with the advice of Dr. Daws where necessary. In terms of cost the scheme has turned out to be comparatively inexpensive in both time and materials.

In the second paper, Mr. R. M. McKenzie (University of Edinburgh) described some of the factors making for good or bad relations between inspectors in industry and the workmen concerned. Some of the factors described involved considerations which were mainly economic, as, for example, where a bonus is paid only for work which has passed the inspector; other factors derived from the organization of the particular factory and the nature of the product, for example, in 'in-process' inspection where the particular products are checked while they are still being made so that any error of man or machine can be put right before a lot of bad work has been done. A third group of factors originate in the more purely human aspects of inspection, the fact that inspection with the prospect of adverse criticism is going on at all, whether or not the inspector is an older person than the general run of those whose work he is inspecting, what length of service he has had with the particular firm, and so on.

A consideration often discussed in connexion with inspection in industry is the nature of the inspector's qualifications for the job. Since the production man must be able to accept criticism from his inspector without losing face, it is a great help if the inspector is at least as well qualified technically as the operator or the charge-hand. He may, however, not need this skill to do the actual inspection. As Mr. McKenzie pointed out, "Many a man can grade an egg who could never lay one, but the man who grades the eggs can tell which hens are no use".

Another aspect of inspection which Mr. McKenzie dealt with was the frequent accusation that inspectors are inconsistent. A number of experiments which he himself had carried out showed that there is more to this criticism than an attempt to save face. In an experiment, for example, in checking sub-assemblies, one inspector rejected five out of a batch of fifty in one day but nine in the next. Another inspector rejected thirteen of the same batch. Two inspection-supervisors, as judges, considered that, in fact, eight were defective. The results of Mr. McKenzie's experiments indicate clearly that the consistency of inspectors should not just be taken for granted. Factors which work against consistency include the fact that very often standards have simply not been clearly laid down. Often, too, the training of inspectors could be improved. Sometimes physical conditions such as the placing of lights or even the boredom of repetitive inspection are factors in poor consistency. It might be asked: Why do not inspector-supervisors check the accuracy of their inspectors? The reason, in practice, is usually found to be that very often relations with production are strained, and, as a consequence, the inspector-supervisor tends to side with his inspectors. The result is that he sees himself first as an inspector and only very secondarily as a supervisor over inspectors.

In his summing up, Mr. McKenzie stressed the importance when picking inspectors of paying particular attention to whether or not they are likely to be acceptable to those over whom they are exercising authority. This is quite crucial since inspection is not just of the product but of the man who has made it; because of this a reasonable working relationship must be established between the two sides. The quite anomalous position of the inspector in regard to both authority and pay in industry at the present time makes this all the more imperative. The inspector, for example, is not the workman's supervisor; very often he has only the same rank as the operator himself, and in many cases receives even less pay. This makes a naturally difficult job even more exacting and underlines the need for appreciation of the importance of such qualities as tact and forbearance in the inspector in industry.

In the third paper, Mr. H. C. A. Dale (University of Cambridge) described an experimental programme on method of approach in fault-finding on which he is engaged. Mr. Dale began by pointing out that the overall efficiency of electronic equipment usually depends on the rapidity with which faults can be located and repaired. In other words, a good deal of the maintenance on it is remedial. Actual repair work usually presents no problem, but fault location does, and good fault-finders are in short supply. Mr. Dale's own research on the subject was aimed at determining the best way of training technicians to do fault-finding in an economic way.

Before addressing himself to the specific aspects of the problem, Mr. Dale gave a short description of basic design in electronic equipment as follows: electronic equipment consists basically of units arranged in chains. A signal or message flows through these chains, each unit making a slight change in it, rather like the way in which small changes are made to the product in a mass-production factory. The fault-finder has to search first for the chain which is faulty, then for the faulty unit, and finally for the component within this unit which is causing the trouble.

The question Mr. Dale then asked was: Can we expect persons to know the best way of searching in a system of this kind, or do they have to be taught? In actual location of faults in electronic equipment when done in the most efficient way, three steps are essential: (1) discover which chain is faulty; (2) locate the faulty unit; (3) find, within this unit, the faulty component.

Put briefly, the golden rule is: general questions are asked first, specific ones later. Mr. Dale then described the results of one of his experiments the main object of which was to see how far this systematic kind of fault-finding is adopted in actual practice. First, he set up laboratory fault-finding problems which involved searching in the same way as in the case of actual electronic equipment. In the particular experiment described, no more than six moves were necessary to locate the fault. The task was given to twenty-four subjects. All were thoroughly familiar with the idea of signal flow. Of the twenty-four, one only used a good solution. Eight of the twenty-four took ten moves or more. The common errors made were to move along in short steps instead of dichotomizing, to check junctions instead of chains, and to go into a chain before first finding if it contained a fault.

After describing the results of this experiment, Mr. Dale went on to tell how he checked his finding against the kind of errors made by electronic engineers searching for real faults in real equipment. The evidence shows that there is a marked tendency to make the same kinds of errors in actual practice. A study carried out by Bryan in the United States, for example, showed that of seventy of the U.S. Navy's best technicians engaged on the maintenance of wireless sets, only 17 per cent of them dichotomized.

Mr. Dale concluded his paper by saying that the results of his experiments to date and those of other relevant studies indicate clearly that we cannot expect electronic engineers to know the best way of searching for faults. They need to be taught, and, it seems, they need to be taught by instructors in technical college, not by experience.

In the last paper of the session Dr. N. R. Cowan, medical officer of health, Rutherglen, Scotland, reported the results of an inquiry into the life-histories and opinions of 443 retired men, aged 65 to 93 years, who attended a Scottish Consultative Health Centre for older people. Approximately 80 per cent of the group had been compulsorily retired. The main purpose of the report on the inquiry given in the paper was to focus attention on the traumatic effect of retirement on the health of older men.

The information for the investigation was obtained from the men on a doctor–patient basis during their visits to the Centre. An analysis of the data showed how far it could be said that the members of the group were leading a 'full' life at the time when the inquiry was made. Three criteria of 'full' were used: physical activities, mental activities, and personal relationships. Each member of the group was given a 'high', 'medium', or 'low' rating on these, and, in addition, a grading for social status based on the occupational classification list of the General Register Office. This ranges through five levels, from class I (professional) to class V (unskilled). The distribution of the group along the five levels inclined towards the lower end: there were 24 in class I (professional) and 83 in class V (unskilled).

The results of the inquiry showed that 'high' ratings on the three criteria of a 'full' life were in no case above 10 per cent for the complete group and that these were found among men in classes I and II. The proportion of 'low' ratings was quite pathetic. In the case of 'mental activities' it was 44 per cent of the group, with 'personal relationships' at 32 per cent. It was apparent that the unskilled workers in the group tended to lead equally unskilled lives.

In the course of the paper Dr. Gowan directed attention to how the harshness of the fact that our economic system does not provide employment for all who wish to work operates to such a deplorable extent against men in the age-group covered in the inquiry. As he pointed out, it is a common occurrence to see older men unsuccessfully seeking work, and also those who have passed through this stage without finding employment, unhappily resigning themselves to retirement. There are, in addition, the partial casualties of compulsory retirement—those who are forced to change their jobs late in life because of age. Of the men in the present group, 79 per cent regarded compulsory retirement as detrimental to the health of older men. One can only agree with Dr. Cowan's suggestion that until society provides some sort of education and preparation for retirement it has a social obligation to provide and subsidize congenial work for those who wish to do it.

This concluded the occupational session. It was a new venture this year in the Psychology Section of the British Association meeting and proved to be a rewarding one.

J. G. McComisky

ANALYTICAL CHEMISTRY, PHARMACY AND MEDICINE

In his chairman's address to the British Pharmaceutical Conference at Llandudno on September 15, Dr. G. E. Foster, chief analyst of Burroughs, Wellcome and Co., expressed a more than personal pleasure in the election of an analyst to the chair. Such an election, he said, was a recognition of the indispensable services which chemical analysis rendered to pharmaceutical science and industry. The names of Scheele, Baumé and Mohr illustrated how analysis and pharmacy had always, in fact, gone hand-in-hand up to the establishment of 'classical pharmaceutical analysis'—a stage which could perhaps be considered as embodied in the British Pharmacopœia of 1932.

In taking as his title "Modern Analytical Chemistry in the Service of Pharmacy and Medicine", Dr. Foster directed attention to the great pharmaceutical value of 'post-classical' developments in analysis. Developments which made it possible to work on very small amounts of material were of particular value, partly because of the very expensive nature of many modern drugs, and also because of their very high potency, which implied that only small amounts would be present in many preparations. For a number of drugs (adrenaline, atropine, carbachol, vitamin B_{12}, digoxin, ergometrine, stilbœstrol and physostigmine being among the examples quoted) the human dose was only a fraction of a milligram.

Classifying these techniques into microchemical and microbiological, Dr. Foster defined microchemistry as "ordinary chemistry carried out on a small scale", and often with the aid of special instruments. Among these, the microbalance had its place; but it should be remembered that colorimetric methods—whether for actual assay of such drugs as morphine, ergot alkaloids or tubocurarine, or for the estimation of impurities such as trace metals—were also essentially microchemical in nature. The use of the photoelectric spectrophotometer in comparing colours of solutions, reducing error to about ± 0·1 per cent as compared with about ± 5·0 per cent in visual comparisons, was given as an illustration of the improved sensitivity which instruments could achieve.

Of microbiological assays, Dr. Foster said these had made their way into very wide and intensive use, calling as they did for little more than standard bacteriological technique and equipment, while effecting great savings of time and expense as compared with experiments on larger animals. Moreover, they could fill the gap when suitable larger subjects were simply unobtainable. Progress in research on the active agents in liver extract had been extremely slow so long as the only subjects known to be suitable for assay were human sufferers from pernicious anæmia. The development of methods measuring the potency of the extracts as growth stimulants for *Lactobacillus* species contributed largely to the identification of folic acid and vitamin B_{12}, while at the same time providing an effective assay.

Microbiological assays were of use for the control of both growth inhibitors (antibiotics and bacteriostatics) and growth promoters (vitamins, etc.). The principles of assessment of the amount of microbial growth from the turbidity of the culture, or from the diameter of the zone of growth promoted or inhibited by diffusion around a spot of the active agent on an inoculated agar plate, were equally useful in either context. For growth inhibitors, serial dilution in order to arrive at the minimal effective dose was also a practical alternative; while for growth promoters, titration of acid liberated in the metabolism of the growing organisms was often the most effective measure of growth.

Successful application of any analytical technique was largely dependent on preliminary isolation of the ingredient sought. In this connexion, Dr. Foster reviewed the group of varied procedures to which the name of 'chromatography' is customarily, though not very perspicuously, applied. Of these, the most universally serviceable is no doubt the solvent partition technique, with paper chromatography as its most usual adaptation. Counter-current solvent extraction, however, might logically be classed as an extreme modification of the same principle. Paper chromatography had been successfully applied in the study of the digitalis glycosides, the identification of the polymixins, the fractionation of liver extract, the separation of the penicillins, and the establishment of the molecular structure of insulin.

Adsorption and ion-exchange chromatography had had more limited though still extensive pharmaceutical uses, especially for isolation of vitamins (for example, D_2 and B_1) before colorimetric determination. Gas–liquid, also known as gas or vapour-phase chromatography, was the most recent arrival, but might well replace analytical distillation, especially for very small amounts of material. It had already been applied to the detection of impurities in Chloroform B.P., and the examination of essential oils seemed an obvious further application.

FORM AND FUNCTION IN THE MOLLUSCA

DURING the meetings of the British Association in Glasgow a session on "Aspects of the Evolution of Form and Function in Molluscs" was held in Section D, those delivering papers being all of them members of the Department of Zoology in the University of Glasgow. In his preliminary remarks, Prof. C. M. Yonge directed attention to the unique features of the Mollusca. The body is primitively bilaterally symmetrical with an antero-posterior axis of growth but over this extends a mantle, attached to the visceral mass and secreting a protective shell, which is initially biradially symmetrical growing by marginal increment. While such conditions continue to exist in the recently discovered monoplacophoran *Neopilina* and in a modified condition (by subdivision or by loss of the shell) in Polyplacophora and Aplacophora, evolution within the Gastropoda, Bivalvia and Cephalopoda represents interaction between the body, essentially head and foot, on one hand, and the mantle and shell on the other. In the Gastropoda a balanced condition often exists, but the mantle may dominate as in the sessile vermetids or it may diminish and disappear as in the opisthobranchs; in the Bivalvia the mantle completely encloses the body and is entirely responsible for external form, so largely controlling habit.

The respiratory chamber of the Mollusca consists of a primitively posterior mantle cavity containing the characteristic gills, paired ctenidia which consist of an axis containing afferent and efferent blood vessels, a branchial nerve and muscles, with rows of filaments alternately disposed on the two sides. Lateral cilia on the filaments set up a respiratory current which flows upward between the filaments within which blood flows in the opposite direction. Supporting rods within the filaments prevent buckling of the delicate tissues; cleansing cilia on marginal surfaces remove particles carried in suspension by the respiratory current.

No organs in the animal kingdom have been more successful or proved more adaptable[1]. With folding of the filamental surfaces and creation of a more powerful respiratory current by pulsations of the funnel and then of the mantle wall, these ctenidia cope with the oxygen needs of modern dibranchiate cephalopods, while with filaments greatly increased in numbers and in individual length they have become organs of feeding in the bivalve Mollusca, the most successful group of ciliary feeders. In the Gastropoda the effect of torsion has been to bring them to the anterior end, and that of asymmetrical coiling of the shell with loss of the marginal slit or apical aperture has been the reduction and loss of the right (post-torsional) ctenidium. In the Mesogastropoda reduction to a single (right) row of filaments on the left ctenidium occurs, but with enhanced efficiency. In the pulmonates the ctenidium is lost but the possibilities inherent in a mantle cavity with vascular walls become apparent, this forming a lung and being possibly the most important factor in colonization of the land and also of freshwaters by Gastropoda.

In the evolution of the Bivalvia[2] the original dome-like shell must have extended marginally and been laterally compressed. The mantle also became attached near to the margin of the shell. The final stage of compression was made possible by reduction of calcification along the mid-line dorsally while at each end there was cross-fusion of the pallial attachments to the shell in the regions of bending. There thus came into simultaneous existence the ligament and the two adductors, the means of opening and of closing the bivalve shell. Complete enclosure of the body by mantle and shell was accompanied by reduction and final loss of the head, feeding being probably taken over by mobile extensions of the lips, the palp proboscides, as in existing protobranchs, for example, *Nucula*[3]. The ctenidia remained primarily concerned with respiration, but further change produced the filibranch and eulamellibranch ctenidia, which collected food, the function of selection being retained by the palp lamellæ. The sensory functions of the head were taken over by the mantle margins, which consisted of an outer lobe concerned with the primitive function of secretion, a sensory middle lobe bearing tentacles and sometimes, as in *Pecten*, eyes, and an inner muscular lobe which controls the volume and site of the inhalant water current. Fusion of the mantle margins[4], to varying extent but initially always by the inner lobes, led to enclosure of the animal and to the formation of siphons enabling bivalves to burrow or bore deeply and yet retain contact with the water for food and oxygen. By the same means the primary ligament—of inner and outer layers with superficial periostracum—could be extended by secondary formation of a fusion layer representing union of the outer surface of the outer lobe of the mantle margins and particularly well shown in the long secondary extension of the ligament posteriorly in *Pinna*[5].

Following up this theme, G. Owen pointed out that the bivalve shell consists of two valves with a connecting ligament, not of two discrete valves united by a ligament of different origin. He noted that the description, as given by D'Arcy Thompson in "Growth and Form", of the growth lines of each valve as a system of closed co-axial lines is incorrect because the growth lines of the two valves are continuous across the primary ligament. Within the shell, loss of the head has the effect of reducing the anterior portion of the body so that in a simple dimyarian bivalve, such as the modern *Glycymeris*, a line drawn from the mid-point of the body dorsally through the middle of the foot divides the animal into almost equal anterior and posterior regions. This line may be designated the 'median axis'. Corresponding division of the mantle and shell is made by way of a line which, starting at the umbones, follows the zone of greatest convexity which in *Glycymeris* leads it to about the mid-point marginally. This demarcation line may be said to separate the mantle and shell into anterior and posterior territories; when projected on to a plane surface it corresponds almost exactly with the median axis of the body.

The form of the shell of a bivalve[6], neglecting here differences between the valves, depends on the growth gradients around the margin of the mantle. If greatest around the mid-point ventrally a symmetrical equilateral shell is formed as in *Glycymeris*. Where growth is greatest posteriorly the shell becomes elongated as in the razor shells (Solenidae)[7,8]. In these the demarcation line is close to the anterior end, the posterior territory being many times the area of the anterior, but the proportions of the body are *not* affected; although by influence of the form of the mantle and shell now bent into a U, the median axis continues to separate approximately equal anterior and posterior regions. The overall effect is formation of a cylindrical shell with short siphons posteriorly and an elongated foot emerging at the anterior end. This makes possible rapid vertical movements by which these bivalves escape danger from predators or from desiccation.

Elongation caused by centres of growth at each end of the mantle produces, by convergence, deep burrowers such as *Mya* (Myacea), *Lutraria* (Mactracea), *Panope* (Saxacavacea) and *Glauconome* (Veneracea)[8]. In all, the median axis and the demarcation line are little altered but there is great elongation of the fused siphons and great reduction of the foot. These animals are immobile deep burrowers reacting to danger solely by withdrawal of the siphons. A final example may be taken from the Tellinacea where, particularly in *Donax*, there is a tendency for enlargement of the anterior territory while, in correlation with the deposit feeding habit (in distinction to the other genera which are all suspension feeders), the animals have both long separated siphons and a powerful foot which enables them to move horizontally within the substratum.

These represent a few instances in which alterations in the form of the mantle and shell influence that of the body with notable effects on habit. Although impossible to discuss here, the opposite condition may occur with changes in the form of the body (probably always initially associated with byssal fixation) affecting that of the mantle and shell[2].

In his communication, Dr. G. E. Beedham directed initial attention to the fact that the ligament and the valves consist of the same three layers formed by the same means, (1) a superficial horny periostracum secreted by the inner surface of the outer mantle lobe and appearing to issue from a 'periostracal groove' between the outer and middle lobes, (2) an outer calcareous (or ligament) layer formed by the outer surface of the outer mantle lobes and (3) an inner calcareous layer formed by the general inner surface of the mantle, this being modified along the mid-dorsal line to constitute the mantle isthmus which secretes the inner ligament layer[9]. These findings he showed to be strengthened by study of the composition of the non-calcareous material (conchiolin) in the shell of *Anodonta cygnea*[10]. The chemical and histochemical properties of the outer layers of the valves and ligament are very similar. The conchiolin from both regions, and also that of the periostracum and the fusion layer of the ligament with which it is comparable chemically, consist principally of a quinone-tanned protein. Acid hydrolysates of this protein were analysed by paper chromatography and found to be rich in phenolic amino-acids, especially tyrosine, and in glycine.

The conchiolin components of the inner shell layers present a contrast. Hydrolysates contain appreciably more aspartic acid and glutamic acid, but much smaller amounts of tyrosine and glycine. Their protein constituents show only slight signs of tanning. In these properties, the inner layers of the valves and ligament appear basically alike. However, each component has certain peculiar features; acid hydrolysates of the inner ligament layer, for example, are characterized by a high content of proline and of the sulphur-containing amino-acid, methionine. These modifications in the protein of the inner ligament may well be correlated with the highly specialized function of this region of the shell.

The divergence in composition between corresponding layers of the valves and ligament may become more extreme in other bivalves. In *Ostrea edulis* and *Mytilus edulis* the outer layers of the valves and ligament each exhibit progressively greater specialization compared with the situation in *Anodonta*. This is most marked in *Mytilus*, where the conchiolin in the outer calcareous layer of the valves has almost the same composition as that in the inner layer, and consequently differs completely in character from that in the outer ligament layer. Nevertheless, in both these bivalves, the inner layers of the shell exhibit properties comparable with those of their counterparts in *Anodonta,* similarity between the inner ligament layers being particularly close.

In considering the evolution of Gastropoda in fresh waters, an account was given by Dr. W. Russell Hunter of work largely carried out at the field station maintained on Loch Lomond by the Zoology Department of the University of Glasgow. The snails of fresh waters are either prosobranchs, retaining the typical molluscan ctenidium and closely related to marine gill-breathing forms, or pulmonates with no ctenidium and the mantle cavity modified as a 'lung'. In both groups different degrees of adaptation to life in fresh waters co-exist, forming functional and morphological series. The ecological and physiological work reported upon was largely concerned with certain species of pulmonate snails, including *Lymnaea peregra, Physa fontinalis* and *Planorbis albus.* Some populations of these snails have to migrate periodically to the surface of the water to breathe[11]. Other populations of the same species can live in deeper offshore water, and a variety of conditions are found in their mantle cavities. In some the 'lung' is water-filled, the snails respiring by some other means, while in others it contains a gas-bubble, which may be used to obtain dissolved oxygen from the water, or merely to give buoyancy[12]. Similar variations between different populations within each species of snail are found in their reproduction: the breeding periods, the numbers of eggs produced, and the survival of the young vary from one population to another. Adaptive plasticity in their methods of breathing, feeding and reproduction is characteristic of freshwater molluscs as a whole. The process of evolution in animals like snails living in fresh waters has been markedly different from evolution in similar animals living in the sea or on land[13]. Freshwater environments are characterized by the high degree of small-scale, short-term isolation which can occur within them. Thus, it seems likely that both the adaptive plasticity found in several aspects of the physiology of freshwater snails, and the co-existence of different degrees of adaptation to limnic life, are associated with the discontinuity in space and the impermanence in time of most fresh waters[13].

A. E. Henderson described his experimental work on the mantle cavity mainly of the larger freshwater pulmonates, *Lymnaea stagnalis* and *Planorbarius corneus.* The use of the 'lung' as an air store for respiratory purposes during submergence has been at least partially supplanted by other functions. Some snails undoubtedly bring the gas-bubble in the cavity into contact with the water during submergence, and can extract sufficient oxygen by diffusional processes to prolong the period of submergence. But other animals, even of the same species, do not do this, and in such cases (perhaps in all) the hydrostatic function of the gas-filled cavity may dominate in determining the behaviour of the animal. In these larger species, the time taken for the bubble to be used up (by the extraction of oxygen to the point where the snail loses its buoyancy) is of the same order as the normal duration of a dive, suggesting that loss of buoyancy may determine the frequency of surfacing. Further, the loss of buoyancy caused by pressure at depth, and the fact that the snails are not found with gas in their cavities at just those depths where they lose their buoyancy, seems to indicate that the hydrostatic can be more important than the respiratory function in some species.

C. M. Yonge

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TIME-SPAN OF DISCRETION IN JOB ANALYSIS

A BOOK by Dr. Elliott Jaques* described a new approach to problems of payment for work involving, among other things, a new way of analysing the work content of roles and a suggested means of measuring responsibility. For the past eighteen months, J. M. M. Hill has been engaged in examining some of the concepts put forward in this book, in testing their validity, and in recommending if and how they should be used for the solution of problems experienced by the Glacier Metal Company, of which he is the policy research officer. In a recent paper† he describes some of the preliminary results of his examination.

The kernel of Jaques's approach may be described as follows. The work activities (or duties) which, under normal conditions of industrial contract employment, a man performs in return for pay may be divided into those that are prescribed (laid down for him so that he has no authorized choice in the matter) and those that are discretionary (in that judgment or the making of choices is called for from him). All jobs—even the most apparently 'routine'—call for some exercise in discretion, and no discretion is allowed to continue indefinitely without being subject to review by a superior. Jobs differ in the maximum length of time that discretion will be allowed to continue before a review takes place, and this maximum length of time—the time-span of discretion—is of fundamental theoretical and practical importance.

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* "Measurement of Responsibility" (Tavistock Publications, Ltd., 1956).

† Tavistock Pamphlets No. 1: The Time-Span of Discretion in Job Analysis. By J. M. M. Hill. Pp. 29. (Reprinted from *Human Relations*, Vol. 9, No. 3.) (London: Tavistock Publications, Ltd., 1958.) 3*s.* 6*d.* net.

The time-span of discretion is a measure of level of work and of responsibility. That time-span of discretion is related to salary, inasmuch as there exists an ascending scale of monetary salaries corresponding to ascending time-spans of discretion. An individual doing a job in industry may be receiving remuneration at, above or below the level appropriate to the time-span of discretion of the job in question. Each of these three possibilities will be associated with different characteristics as regards the satisfaction and behaviour of those concerned. In particular, payment at the appropriate level will be experienced by the individual as satisfactory—he will not actively press for increase and will not express disruptive disaffection.

If Dr. Jaques's hypothesis is correct, it is a matter of fundamental importance to industry and may even provide a basis on which the apparently intractable problems of differentials may be settled. Before such notions and other economic implications of the idea may be investigated, Dr. Jaques's findings must be checked by observation and experiment and the actual time-span of discretion of jobs must be determined.

In the course of his work, Mr. Hill has been concerned with assessing the time-span of jobs and with the communication of the means of such assessment. In his paper the dependence of the existence of a clear time-span of discretion of a job on the existence of a clearly structured work situation is described, and some of the implications of this examined. Problems of assessing time-span in situations of unclarity are also discussed. The meaning of the term discretion is then described, expanded and exemplified, and reference made to some of the difficulties that may be met in discovering the discretionary aspects of a job. A review mechanism is then defined as any systematic means by which a manager becomes aware of the quality of his subordinates' use of discretion, and this definition is expanded and exemplified. Three kinds of review mechanisms discovered are described as:

Direct review, in which a subordinate hands back a completed piece of work to his manager for full inspection.

Indirect positive review, in which a manager deliberately seeks information about the way in which his subordinate has been using discretion, from sources outside that subordinate's control.

Indirect negative review, in which a manager relies on the fact that he will hear of the matter should his subordinate use discretion inadequately.

Jobs are then grouped as 'single aspect' or 'multiple aspect' according to whether only one or many different kinds of work activities are carried out. The boundaries between the different aspects of a multiple-aspect job are termed either 'permeable' or 'impermeable' according to the extent to which a review of discretion in one aspect leads to review of other aspects.

Within the framework given, a job may be set up in reality with a range of possible time-spans of discretion, and that within discoverable limits managers have choice concerning the time-span of discretion that they will allow a subordinate.

A description is also given of the means by which information about jobs may be elicited in order that the time-span of discretion may be assessed. Three examples of time-span analysis are presented and discussed. In each case the analysis concerns a particular kind of work, namely—the work of a draughtsman, a manual operator's work, and research work.

In future papers it is hoped to present an analysis of line management jobs, to examine the relationship of time-span with salary, to describe the use of the time-span instrument for organizational design, and to examine the implications that the use of such an instrument has for personnel management and for work study in industry.

EVIDENCE FOR PERMEABILITY MINIMA IN LOW-PRESSURE GAS FLOW THROUGH POROUS MEDIA

By Dr. D. M. GROVE and M. G. FORD

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FOR a gas flowing in a porous medium at a pressure such that λ, the mean free path of the gas molecules, is much less than $2r$, the mean pore diameter, it is well established[1] that there is a linear relationship between K, the permeability (cm.²/sec.), and $\bar{p}$, the mean pressure of the gas in the porous medium. Among the various equations put forward to represent such flow is that developed from the Kozeny equation by Carman and Arnell[2,3], which may be written as:

$$K = \frac{\varepsilon^3 \bar{p}}{k\eta A^2} + \frac{8}{3}\frac{\delta\varepsilon^2}{k'A}\sqrt{\frac{2RT}{\pi M}} \qquad (1)$$

where ε = porosity (cm.³/cm.³) of the porous medium; A = specific surface area (cm.²/cm.³) of the porous medium; k = Kozeny constant (5·0); k' = shape factor (2·0 to 2·5 for most porous media); η = viscosity of the gas; M = molecular weight of the gas; and δ = a coefficient of the order of unity.

All equations for slip flow are of the form[4]:

$$K = K_p\bar{p} + \delta K_k \qquad (2)$$

where K_p is the Poiseuille (viscous) flow and K_k is the contribution due to slip of the gas molecules at the pore walls[5]. The slip term is of the same form as the expression for Knudsen (molecular) flow, which for a porous medium may be written as[6]:

$$K_k = \frac{8}{3}\frac{\varepsilon^2}{A}\sqrt{\frac{2RT}{\pi M}} \qquad (3)$$

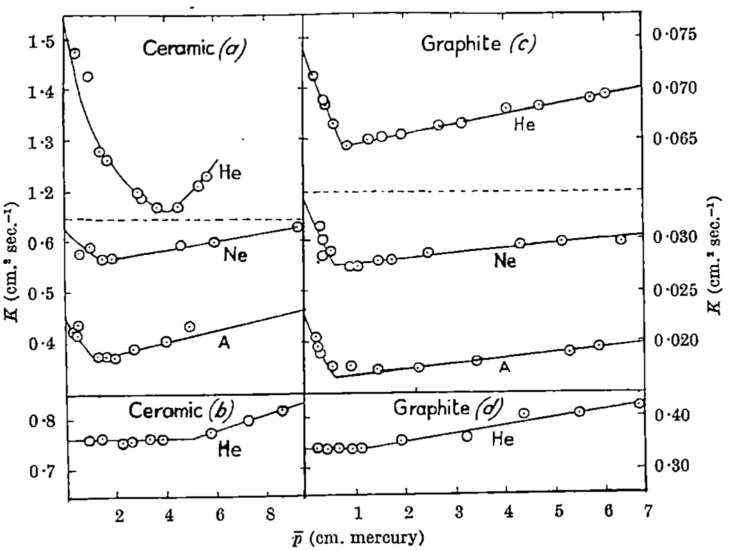

Fig. 1. Flow of inert gases at 25° C. through porous ceramics and through graphites

where the mean hydraulic radius $m = r/2$ is replaced by ε/A, assuming that the porous medium consists of uniform capillaries. An additional factor ε is introduced because flow occurs only in the pores and not through the entire cross-section.

At low pressures, when $\lambda \gg 2r$, viscous flow gives place to molecular streaming, the permeability K becomes independent of the mean pressure $\bar{p}$, in accordance with equation (3). A flattening of the permeability curve at low pressures has been observed by several workers[7,8]. Conversely, for materials having extremely fine pores, there may be no measurable Poiseuille contribution even at pressures of half an atmosphere[9,10]. Considerable discussion[11] has taken place concerning the numerical constants of K_p and K_k, including the shape factors k and k', and various values have been given to the coefficient δ, which appears to alter both with the mean pressure of the gas and with the material of the capillaries.

Gas flow in a single capillary also gives a linear relationship between K and $\bar{p}$ in the region of slip flow, but instead of the flattening at low pressures, a minimum is observed[12–14] in the permeability curve. More recently, Huggill[15] has obtained indications of such a minimum using a block of 1,400 capillaries of polymerized methyl methacrylate. Only a few tentative claims[16,17] have been made for permeability minima in porous media. Pollard and Present[18] have shown theoretically that a minimum is not, in fact, to be expected, since mean free paths much greater than the pore diameter will not occur in the tortuous and irregular capillaries of a porous medium.

Using consolidated porous media, we have now obtained several examples of quite marked permeability minima, some of which are shown in Fig. 1. The curves (*a*) for the inert gases flowing through a porous ceramic were the first we obtained of this type; the curves (*c*) for a relatively impermeable graphite are examples of the higher degree of accuracy obtained more recently. The existence of a minimum cannot be solely a property of the material of the porous medium, since (*b*) and (*d*), which are curves for other grades of ceramic and graphite, respectively, show a flattening at low pressures instead of a minimum. Nor does the minimum depend in a simple way on the mean pore radius calculated from the slope of the linear portion of the permeability curve. Table 1 gives the porosity ε determined by density measurements or helium displacement. This has then been used to calculate the mean pore radius, $r = 2\varepsilon/A$, and the specific surface area A from the first term in equation (1).

The results suggest that pore size distribution, rather than the mean pore radius, may be the factor which determines whether or not a minimum is observed.

Preliminary measurements of the surface areas of the ceramic and graphite samples by the standard Brunauer–Emmett–Teller method give in each case results between five and seven times greater than the values of A shown above. It is to be expected that permeability measurements will give a lower result since gas flow will occur mainly through the large pores and any blind pores will not take part, whereas the small pores, whether blind or not, will make a relatively greater contribution to the Brunauer–Emmett–Teller surface area[9].

Table 1

Porous medium	ε (cm.^{3}/cm.^{3})	$r \times 10^4$ (cm.)	A (cm.^{2}/cm.^{3})
Ceramic (*a*)	0·442	0·91	9,760
Ceramic (*b*)	0·280	1·30	4,320
Graphite (*c*)	0·183	0·348	10,520
Graphite (*d*)	0·174	1·61	2,160

The mean pressure corresponding to the minimum varies with the gas used, but for each sample the mean free path of the gas molecules is approximately constant at that pressure. For the ceramic (*a*) it is about seven times the mean pore radius, and this agrees with the results of Knudsen[12] and others for a single capillary, for which the ratio λ/r at the minimum is about 10. For the graphite (*c*), however, the ratio is 50. It is interesting to note that both for ceramic (*b*) and graphite (*d*) the end of the flat portion of the permeability curve corresponds closely to the position of the minimum for other grades of the same material, although the pore radii of the two graphite samples differ so widely.

This work will be published and discussed in more detail elsewhere.

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CONDENSATION PRODUCED BY ULTRA-VIOLET LIGHT

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IT was discovered by Lenard and Wolff[1] that the exposure of a damp gas in a cloud chamber to ultra-violet light may result in a marked increase in the condensation on expansion. Their experiments indicate that the ultra-violet light (although of too long wave-length to cause ionization) may form some kind of uncharged condensation nuclei. C. T. R. Wilson[2] investigated the effect in air saturated with water vapour, and ascribed it to the formation of hydrogen peroxide. He reported, however, that an increase in condensation could also be observed when the air was replaced by carbon dioxide or by hydrogen. More recently, Crane and Halpern[3] observed the effect in a conventional cloud chamber with an air – ethyl alcohol filling, and they attributed it to the formation of atomic oxygen. This theory was supported by Farley[4], who investigated the condensation of water vapour in a rubber-diaphragm cloud chamber. McHenry and Twomey[5], on the other hand, attributed the increased condensation observed with water vapour to the presence of an ammonia contamination in the air. It is evident that there still exists considerable doubt as to which component of the gas – vapour mixture is responsible for the effect. The present investigation was therefore undertaken with the object of ascertaining the origin of the condensation nuclei.

The initial experiments were performed with various gas – vapour mixtures in a conventional rubber-diaphragm cloud chamber. Light from a mercury discharge lamp equipped with a quartz lens was brought to a focus inside the chamber through a quartz window. At an expansion ratio normally just sufficient for the onset of spontaneous condensation, prior exposure to ultra-violet light produced a dense cloud. In these and in the subsequent experiments every fast expansion was always followed by a series of slow expansions to clear the chamber. The effect was studied using water as condensant and the following permanent gases in turn: room air; cylinder oxygen, nitrogen and argon; and, finally, cylinder nitrogen and argon which had been passed over heated copper to remove residual oxygen. No significant differences in the condensation could be seen with the different gases; such differences as were observed could always be explained in terms of the different rates of diffusion of the nuclei through the gases and/or the different ratios of the specific heats of the gases. It was noticed, however, that for a particular filling the density of the cloud due to ultra-violet irradiation increased markedly with time, attaining an equilibrium value after a few days. A similar effect was noticed when using ethyl alcohol as condensant. These experiments indicate that the nuclei do not arise from the permanent gas, but from a contamination given off by the chamber materials (probably by the rubber diaphragm).

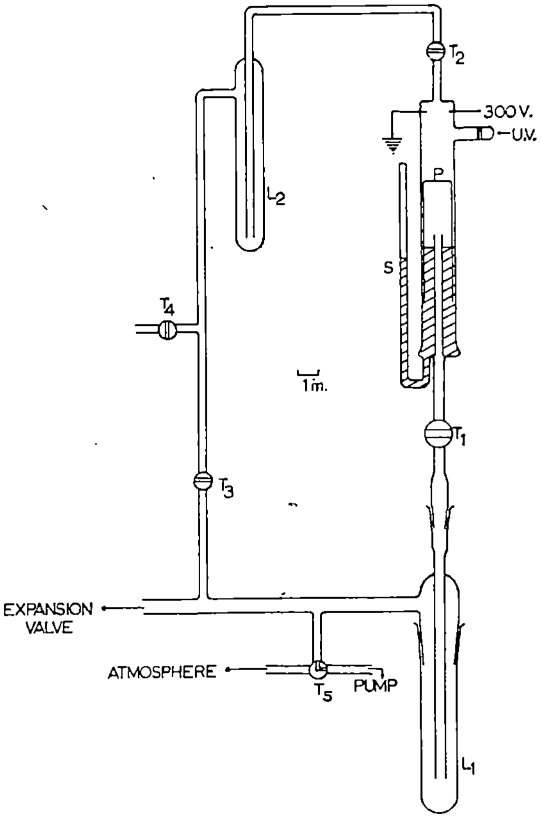

Fig. 1

To check this conclusion the chamber illustrated in Fig. 1 was constructed, and operated with water as condensant. In this chamber only glass, quartz, water and tap grease ('Apiezon *L*') came in direct contact with the working volume. (The tap T_2 could not be eliminated since preliminary experiments revealed that in sealing off a 'Pyrex' tube numerous nuclei are produced on irradiation.) All gases admitted to the chamber, either during the filling process or the operation of the chamber, first passed through the traps L_1 or L_2 surrounded by liquid air (or solid carbon dioxide). Ultra-violet light was admitted through the quartz tube Q fused to the chamber via a graded seal. To make an expansion, the space underneath the piston P was suddenly connected to a partially evacuated vessel through a magnetically controlled valve (the tap T_1 being open). The expansion ratio was controlled by adjusting the pressure in the partially evacuated vessel.

Before using the chamber, the tube above T_2 was broken, the chamber removed and washed out with a 1 : 1 mixture of concentrated sulphuric and concentrated nitric acid. Steam generated in an all-glass apparatus was then passed through the chamber for

15 hr. The distilled water used as condensant was prepared by the method recommended by Faure *et al.*[6]. De-ionized water was distilled from a mixture of potassium permanganate and sodium hydroxide and then directly into the chamber from phosphoric acid. A tin condenser was used in the final stage to avoid the impurities dissolved by water when condensing on glass. After filling, the taps T_1 and T_2 were closed, the chamber replaced and the tube above T_2 again sealed to the rest of the apparatus. To fill the chamber with clean gas, the taps T_1, T_2 and T_3 were opened and the apparatus slowly evacuated through T_5. The taps T_1 and T_5 were then closed and the gas admitted through T_4. This process was repeated a few times. Finally, the tap T_1 was closed, and the chamber pumped out slowly through T_2 until the piston rose to the desired height.

A 125-W. high-pressure mercury-discharge lamp was used in conjunction with this chamber, and the drops could readily be observed in its light. Expansions were made at the same ratio alternately with and without a glass filter in the beam, and the number of drops estimated visually. (It was checked that the glass filter removed completely tho wave-lengths responsible for the nuclei.)

With room air as the permanent gas, exposure to ultra-violet light still caused the number of drops to increase by a factor of the order of 10. If, however, the air was first passed through phosphoric acid in a bead tower and then through the liquid air trap L_2, no increase in the condensation could be detected on exposure.

It can therefore be concluded that the vast majority of nuclei (if not all) usually observed with water vapour is due to some contamination. If any nuclei are formed with distilled water and purified air, the number is too small to be detected with our technique. So far as we can see, no particular care had been taken by previous workers to eliminate impurities, and these impurities could have given rise to the observed effects.

Wilson[2] also found that a cloud could be formed by merely irradiating damp air with an intense ultra-violet beam. His experiment was repeated using a glass vessel with a quartz tube fused to it via a graded seal. With distilled water and room air in the apparatus, no cloud could be seen even after irradiating for about 10 hr. When traces of impurities (such as carbon tetrachloride or ammonia) were introduced, however, a cloud formed after exposing for a few seconds. With pure carbon tetrachloride (fractionally distilled from a 10-ft. column containing stainless steel rings) a cloud of small drops could also be formed by irradiation only.

No explanation of the mechanism of the condensation process is attempted at this stage. Further investigation is necessary, and the work is being continued.

This investigation was started by one of us (A. J. B.) at the Department of Natural Philosophy, University of Glasgow. We wish to thank Prof. P. I. Dee and Mr. J. R. Atkinson for their interest and for helpful discussions.

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DIRECT RECORDING OF FLUORESCENCE EXCITATION SPECTRA

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THE use of absorption spectroscopy for the identification of unknown substances is limited to concentrations of 10^{-5} *M* or more, the measurement of a complete absorption spectrum at lower concentrations than this requiring an inconveniently long optical path. The measurement of fluorescence emission spectra as a means of identification at much lower concentrations is now becoming commonplace, but unfortunately the fluorescence emission spectrum alone is, in general, not so specific as the absorption spectrum because it corresponds to transitions only from the lowest excited state of the molecule, irrespective of the wave-length used for excitation. Previous work in this laboratory[1] has shown that the measurement of the fluorescence excitation spectrum provides a method of identification which is as specific as the absorption spectrum and can be made at far lower concentrations. It was suggested[1] that the 'true' fluorescence excitation spectrum should be defined as the fluorescence output (of a sufficiently dilute solution) measured as a function of the frequency of the exciting light at constant quantum intensity. Under these conditions the fluorescence output is proportional to the product of the fluorescence quantum yield, φ, and the extinction coefficient, ε, of the fluorescent substance, and for many substances where φ is independent of frequency, the excitation spectrum is identical with the absorption spectrum. It has the advantage over the absorption spectrum that it can be measured in the presence of other strongly absorbing substances provided that sufficiently dilute solutions are used. Weber and Teale[2] have recently also discussed these points. They have investigated the fluorescence excitation spectra of a variety of organic compounds in solution and report a list of twenty-six compounds for which the fluorescence quantum yield is constant over a wide range of wave-lengths. They have also described conditions under which the fluorescence yield may not be constant, and the useful conclusions which can be drawn from a comparison of the excitation and absorption spectrum of a pure substance.

It is unfortunate that most spectrofluorimeters record only the apparent excitation spectrum, that

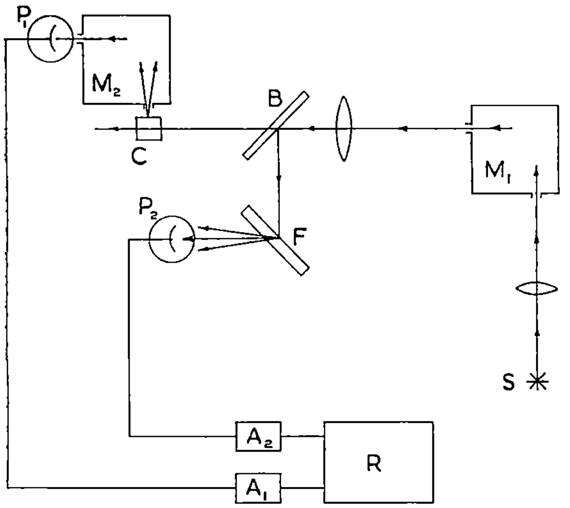

Fig. 1. Arrangement for recording true excitation spectra

is, the product $I\varphi\varepsilon$ versus frequency or wave-length, and since the intensity (I) available at the exit slit of the monochromator used to isolate the exciting light often varies considerably with frequency, the spectrum observed is seriously distorted and important features may be missed entirely. The true excitation spectrum can, of course, be calculated from the observed spectrum by measuring the spectral intensity of the light reaching the fluorimeter cell, but this calculation is time-consuming, particularly when a large number of experiments have to be made.

The value of the method in analytical chemistry would obviously be greatly increased if the true excitation spectrum (or a close approximation to it) could be directly recorded by the spectrofluorimeter. The arrangement shown in Fig. 1 has been designed for this purpose. The exciting light from the monochromator M_1 is focused on the sample in cell C, but a small proportion of the beam is reflected by the clear silica plate B on to the front surface of the fluorescent screen F. This consists of a silica cell, 5 mm. optical depth, containing a suitable fluorescent solution the fluorescence of which is viewed through the back face of the cell by the monitoring photomultiplier P_2. A suitable band of fluorescent light from the sample in C is selected by the monochromator M_2 and is received by the photomultiplier P_1. After amplification the outputs of P_1 and P_2 are passed to the ratio recorder R. The frequency drum on M_1 is motor driven, and as the frequency is varied the slits are adjusted so as to maintain the output of P_2 approximately constant (within a factor of 2). If the contents of F are suitably chosen, the output of P_2 can be made proportional to the quantum output of M_1 over a wide frequency-range. R then records the true fluorescence excitation spectrum of the sample in C.

Fluorescent solutions chosen for the monitoring cell F should ideally have constant fluorescence yield and absorb substantially the whole of the beam within a depth of about 1 mm. or less, over the whole spectrum-range concerned. Thus the fluorescent light has to penetrate a further 4 mm. of solution before reaching P_2 and this solution thus acts as a filter for the exciting light and at the same time ensures that substantially the same band of fluorescent light reaches P_2, irrespective of the depth of penetration of the incident beam[3]. In preliminary experiments a solution of $4 \cdot 4 \times 10^{-3}$ M fluorescein in a mixture of sodium carbonate and bicarbonate (both $0 \cdot 1$ N) was used. Although the fluorescence yield of this solution is not precisely constant[4] it was sufficiently so for these preliminary trials. The apparent relative fluorescence yield of this solution was determined by measuring the dose-rates of monochromatic ultraviolet light received by the contents of the cell, C, using the ferrioxalate actinometer[5] and comparing these with the corresponding readings of P_2. A Siemens xenon arc lamp type XC was used as a source of light with Hilger $D247$ quartz prism monochromators for M_1 and M_2. Rather large fluctuations in light intensity were observed, and a number of experiments were done at each wave-number setting of M_1. The mean results for the apparent relative efficiency of the monitoring screen (column 5 of Table 1) are accurate to about ± 5 per cent. They represent the correction which must be applied to the observed output of P_2 to obtain the relative intensity received by the contents of C. (They do not represent precisely the true relative fluorescence quantum yield of the contents of F owing to changes of reflectivity of the beam-splitter B and the transmission of the cells F and C.) The overall deviation from linearity is ± 10 per cent. This is adequate for many purposes without applying the correction. The linearity can no doubt be improved by choice of a more suitable solution for F. The range (which with fluorescein extends to below $2 \cdot 0\mu^{-1}$ before transmission becomes appreciable) can be extended to somewhat lower wave-numbers by the use of a solution of rhodamine B in ethylene glycol[6].

The excitation spectrum of 1 : 2-benzanthracene in ethanol recorded with the present apparatus is shown in Fig. 2 alongside the absorption spectrum as measured with a Unicam $SP500$ spectrophotometer. The excitation spectrum shows all the features of the absorption spectrum although it is not identical with it owing to the differing band-widths used. The excitation spectrum of a substance of biological interest, 5-hydroxytryptamine (present as the creatinine sulphate complex), is shown in Fig. 3 (curve 1). The fluorescence of this substance occurs entirely in the ultra-violet region (maximum at $2 \cdot 9\mu^{-1}$). The excitation spectrum is similar to the absorption spectrum and is clearly a much more useful record than the second curve which was recorded at constant slit width without the use of the fluorescent screen

Table 1. APPARENT RELATIVE FLUORESCENCE EFFICIENCY OF MONITORING SCREEN

($4 \cdot 4 \times 10^{-3}$ M fluorescein in a mixture of sodium carbonate and bicarbonate, both $0 \cdot 1$ N).

Mono-chromator setting (μ^{-1})	Half-band width of slit setting (μ^{-1})	Light intensity on fluorimeter cuvette (einsteins/min. × 10^{9})	Monitor reading (arbitrary units)	Apparent relative efficiency of monitor
2·2	0·016	0·90	1·08	1·20
2·4	0·025	2·05	2·18	1·06
2·6	0·023	1·17	1·29	1·10
2·8	0·020	0·77	0·77	1·00
3·0	0·037	1·88	2·05	1·09
3·2	0·034	1·35	1·40	1·04
3·4	0·046	1·47	1·55	1·05
3·6	0·057	1·46	1·49	1·02
3·8	0·065	1·08	1·15	1·06
4·0	0·085	1·06	1·15	1·08
4·3	0·078	0·234	0·257	1·10

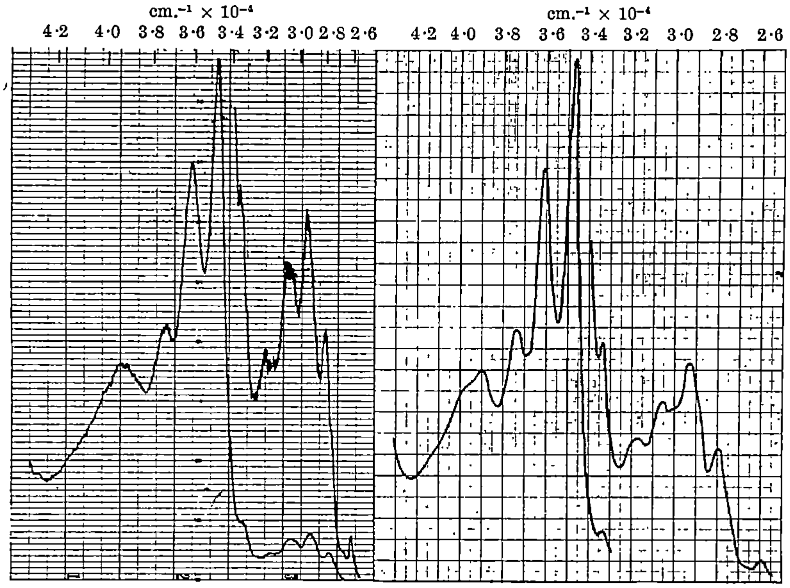

Fig. 2. 1 : 2-Benzanthracene in ethanol. Left, excitation spectrum with fluorescence observed at 2·25–2·45μ^{-1}; right, absorption spectrum

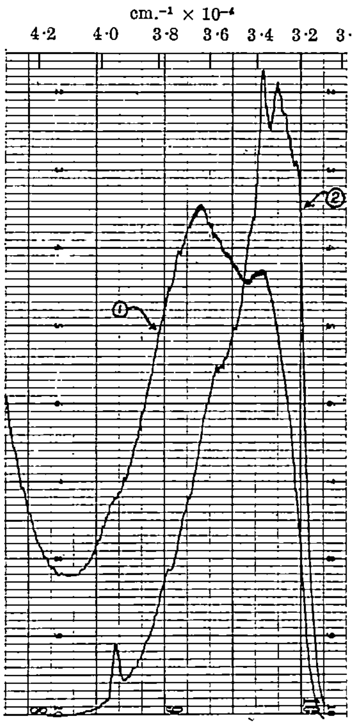

Fig. 3. 5-Hydroxytryptamine creatinine sulphate in water. Excitation spectrum recorded with (curve 1) and without (curve 2) the monitor. Fluorescence observed at 2·85–3·0μ^{-1}

monitor. Owing to the rapid change in the intensity of the exciting light with frequency the latter bears little resemblance to the absorption spectrum of the compound.

The present measurements were made using a monochromator for the isolation of both the exciting and fluorescent light. Owing to the comparatively narrow aperture of the monochromators, the intensity of the fluorescent light available at P_1, and hence also the overall sensitivity, was limited. The tests on 1 : 2-benzanthracene and 5-hydroxytryptamine shown in Figs. 2 and 3 were done with comparatively concentrated solutions ($10^{-6}\,M$ and $10^{-5}\,M$ respectively). Satisfactory spectra could be obtained with concentrations one hundred times less than these values although there was an inevitable increase in the noise-level on the curves, and the fluorescence 'blank' also became appreciable. For example, the excitation spectrum of 5-hydroxytryptamine is shown in Fig. 4 recorded at a concentration of $10^{-7}\,M$ (upper curve). The lower curve on this figure is the corresponding 'blank' obtained with pure water in the cell. Instrumental sensitivity can be increased considerably by the use of filters to isolate the fluorescence for P_1, but at the expense of some versatility and convenience. (The choice of secondary filters is sometimes very difficult with substances fluorescing in the ultra-violet region.) When working at very low concentration great care must be taken to avoid interference by fluorescence or scatter from solvent and by fluorescence of cell or secondary filters. It is, of course, always necessary to take measurements with pure solvent in the cell to determine the magnitude of the 'blank' excitation curve.

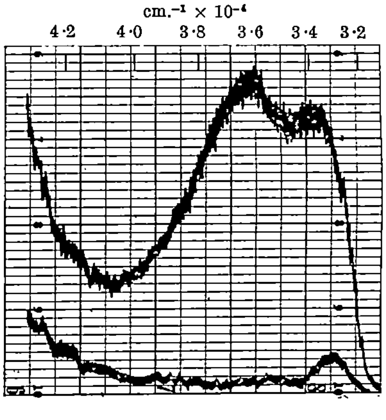

Fig. 4. Excitation spectrum at high sensitivity. Upper curve, $10^{-7}\,M$ 5-hydroxytryptamine creatinine sulphate in water; lower curve, water alone

I thank Dr. E. J. Bowen for much helpful discussion. I also wish to acknowledge the assistance rendered by Mr. C. G. Hatchard, who carried out the chemical actinometry.

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LETTERS TO THE EDITORS

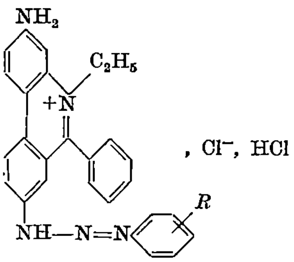
The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Metamidium: a New Trypanocidal Drug

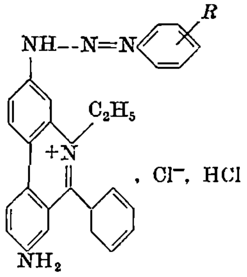
THIS communication describes a new trypanocide, which has been found to possess considerable potentiality as a curative and as a prophylactic drug, both in laboratory experiments and in field trials carried out in Africa during the past year.

In following up the long-standing interest in these laboratories in the trypanocidal activity of both phenanthridinium salts[1] and the aromatic diamidines[2], we decided to prepare the *p*-amidinophenyldiazoamino-derivative[3] of 2 : 7-diamino-10-ethyl-9-phenylphenanthridinium chloride (homidium chloride). The diazoamino linking group was selected because of the structural relationship our product would then bear to the recently introduced curative trypanocidal drug 'Berenil', *p*-amidinophenyldiazoamino-*p*-benzamidine[4].

The coupling reaction between diazotized *p*-aminobenzamidine (1 mol.) and homidium chloride in the presence of sodium acetate (7 mol.) at a temperature of 0–5° C. yields a mixture of two isomeric *p*-amidinophenyldiazoamino-derivatives, which can be separated by precipitation from water with sodium chloride, followed by fractional crystallizations from water and from methanol. The relatively water-insoluble isomer, m.p. 287–289° (dec.), was purple and the other, m.p. 236–240° (dec.), red. Both isomers were self-indicating on paper electrophoresis in 3 *N* acetic acid, the purple isomer being distinctly more mobile than the red; this provided an invaluable means of following the progress of separation procedures.



(I)



(II)

Since in 2 : 7-diamino-10-methyl-9-phenylphenanthridinium chloride (dimidium chloride) it is the 7-amino-group which reacts preferentially on acetylation[5], we provisionally assigned the structure (I; *R* = *p*-amidino) to the predominating purple isomer and (II; *R* = *p*-amidino) to the red isomer. Work to provide unambiguous proof of structure continues. A diazoamino structure was expected from the method of preparation and the expected microanalytical figures were obtained for both isomers. Infra-red spectra ruled out the remote possibility that the isomers were due to the existence of two stable tautomeric forms of the diazoamino-group in one or other of the structures (I) or (II). The presence of a diazoamino-group in each isomer was confirmed by the rapid evolution of nitrogen on boiling in 6 *N* sulphuric acid—the red isomer yielded nearly the theoretical volume of nitrogen, while the purple regularly yielded only about 65 per cent (the reason for this deficiency is at present unexplained).

The very promising results obtained on testing the isomers (I and II; *R* = *p*-amidino) as trypanocides led us to study extensively structure/activity relationships among similar pairs of isomers, particularly those in which the substituent *R* and the group in the phenanthridine-10 position were varied. As a result, we found that the most promising product was a mixture of the two isomers (I and II; *R* = *m*-amidino)[6], first designated M & B 4404, and later

Table 1. TOXICITY AND THERAPEUTIC ACITIVITY AGAINST *T. congolense* IN MICE

Compound having structure I or II	Substituent *R* in structures I or II	*LD*50 (mgm./gm.) subcutaneous	*CD*50 (mgm./gm.) subcutaneous		
			Strain of *T. congolense*		
			Laboratory (*a*)	Kenya (*b*)	Sakwa XXIV (*c*)
Purple isomer	*p*-amidino	1·0	0·002		
Red isomer	,,	0·30	0·00075		
Purple isomer	*m*-amidino	0·43	0·00003		
Red isomer	,,	0·26	0·000002		
Compound					
Metamidium chloride hydrochloride		0·23	0·000008	0·003	0·00004
Metamidium suramin salt		>5·0	0·000027		
Homidium chloride		0·07	0·00003	Not curative at 0·01	0·0015

(*a*) Isolated in Tanganyika in 1933. (*b*) Isolated in Kenya in June 1956. (*c*) Isolated at Sakwa (Kenya) in December 1956.

Table 2. PROPHYLACTIC ACTIVITY AGAINST THE LABORATORY STRAIN OF *T. congolense*

Compound having structure I or II (*R* = *m*-amidino)	Dose (mgm./gm.) subcutaneous	Number of mice protected out of number challenged								
		2	3	4	8	9	12	16	20	26
		(weeks after dosing)								
Purple isomer	0·025		5/17	1/8	0/11					
Red isomer	0·025		11/11		6/6		8/8	5/7		
Compound										
Metamidium chloride hydrochloride	0·025			12/12	12/12		6/6	10/11	6/10	0/5
	0·005			4/4	6/6	5/6				
	0·001	6/6		5/6		0/3				
Homidium chloride	0·025	1/10								
Berenil	0·06	0/10								

assigned the common name metamidium chloride hydrochloride.

In metamidium the two isomers are present in the same relative proportions (approximately 55 per cent purple isomer and 45 per cent red isomer; Campbell, H., and Muggleton, D. F., private communication) as are formed in the coupling reaction between diazotized *m*-amino-benzamidine and homidium chloride. Both isomers have been separated by methods similar to those described above for the *p*-amidino series, to give a purple isomer, m.p. 258–260° (dec.), and a red isomer, m.p. 244–245° (dec.), both in the form of their chloride hydrochloride salts. Metamidium chloride hydrochloride is 12·5 per cent w/v soluble in water at 25°, the *p*H of a 1 per cent solution being 6·65.

The suramin salt[7] of metamidium, designated M & B 4427, was precipitated and dried *in vacuo* at room temperature to give a dark purple powder, which was less than 20 μgm./ml. soluble in water at 20° C. For biological evaluation this solid was presented as a 10 per cent w/v ball-milled aqueous suspension.

The foregoing compounds were examined for activity against a laboratory strain of *Trypanosoma congolense* which gave an acute infection in mice. A single subcutaneous injection was administered to mice with an infection in the peripheral bloodstream of from 1–10 trypanosomes per high-power field. Ten mice were used for each dose, and five untreated controls which died within 5–7 days were included in each experiment. Homidium chloride was used as a standard.

Wet blood smears were examined three times a week for four weeks, and the number of animals clear of trypanosomes for that period (that is, cured) was noted for each dose. The *CD*50 (the dose which cured 50 per cent of the mice) was then obtained graphically for each compound using de Beer's method[8]. The subcutaneous *LD*50 for each compound was also obtained in mice.

The results of these therapeutic and toxicity experiments are given in Table 1, together with the results obtained with metamidium and homidium against two more recently isolated strains of *T. congolense*, which we obtained through the courtesy of the East Africa Trypanosomiasis Research Organization, Tororo, and the Veterinary Research Laboratory, Kabete. These experiments were carried out less than twelve months after the strains were isolated.

These results show that metamidium chloride hydrochloride was more active than homidium chloride against all three strains of *T. congolense.*

Prophylactic experiments in mice were also carried out with some of the compounds. In these experiments a single subcutaneous injection of the substance was given to a large batch of mice and groups of them were challenged intraperitoneally with approximately 65,000 *T. congolense* (laboratory strain) per mouse at various times after dosing. No mouse was challenged more than once.

The mice were examined for trypanosomes for four weeks after challenge, as in the therapeutic experiments, and those which remained clear of trypanosomes for this period were considered to have been protected. Untreated controls were infected at each challenge and these became positive for trypanosomes within five days.

The results of these experiments are given in Table 2.

Metamidium chloride hydrochloride completely protected mice for up to sixteen weeks at about one-ninth of the *LD*50. This was an interesting result because neither the parent compound, homidium chloride, nor the drug 'Berenil', with which metamidium shares some structural similarities, has any appreciable prophylactic activity at one-third of the *LD*50.

Of the two isomers of metamidium, the red was more active than the purple both therapeutically and prophylactically, but there was little difference in their toxicities.

We thank Dr. H. J. Barber and Dr. R. Wien for the constructive interest they have taken in this work.

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A Rate-Governing Reaction of Protein Synthesis

RABBIT reticulocytes synthesize hæmoglobin *in vitro*. In order to maintain a high rate for at least four hours there needs to be added to the saline solution in which the cells are suspended a mixture of amino-acids, glucose, iron and an iron-chelating agent. The rate then (in four hours) is about five times that in saline alone. Glucose, iron and chelating agent have little effect on the rate unless the amino-acid mixture is added with them[1].

When in a reaction mixture complete except for one amino-acid, and that amino-acid is added in the carbon-14-labelled form and in varying concentration, the rate of its incorporation was found to vary as a first approximation with the concentration according to the equation $\frac{v}{V} = \frac{[A]}{[A] + K}$, where v is the observed rate at any given concentration, V is the maximum rate, $[A]$ is the concentration of the labelled amino-acid added to the reaction mixture and K is constant, which is formally identical with K_m in the Michaelis–Menten equation, that is to say, it is the equilibrium constant for the combination of substrate with enzyme. In the present instance $K = \frac{[B][A]}{[BA]}$, where B is a substance in the cells with which $[A]$ combines, and the rate of incorporation (fraction of the maximum) is proportional to $\frac{[BA]}{[B][BA]}$. The term $[BA]$ governs the rate of protein synthesis.

Table 1

Molar concentration of labelled leucine	Counts for 20 mgm. protein in 60 min.	Observed percentage of the maximum rate	Calculated percentage of the maximum rate for $K = 1 \cdot 25 \times 10^{-5}$
1×10^{-3}	3,369	100	100
5×10^{-4}	3,276	97	97
1×10^{-5}	1,608	47	44
5×10^{-6}	884	26	28
$2 \cdot 5 \times 10^{-6}$	598	17·7	16·6
$1 \cdot 0 \times 10^{-6}$	249	7·4	7·4
5×10^{-7}	107	3·2	2·4

Table 1 gives the results of a typical run. 0·25 ml. of packed reticulocytes was suspended in 32 ml. of a complete reaction mixture[1] except for labelled leucine, the concentration of which was varied. The temperature was 25° C., the incubation time 15 min. The proteins were washed and counted as previously described.

In different experiments the values of K varied over the range $0 \cdot 7 \times 10^{-5}$ to $1 \cdot 5 \times 10^{-5}$, but the variation within each run with concentration of leucine was according to the above equation. Preliminary experiments with labelled histidine, methionine and phenylalanine indicate that their minimum concentration for maximum incorporation was the same as that of leucine, namely, approximately 10^{-3} M, and also that their equilibrium constant was of the same order, namely, about 1×10^{-5}. The cause of the small variations from experiment to experiment needs to be understood before anything can be said regarding the value of K for different amino-acids. There may be a number of inter-related equilibrium reactions, and the value of K which is calculated would then be that for the overall equilibrium.

As there were maximum amounts of all the amino-acids needed except the labelled amino-acid the incorporation of which was measured, it follows that the hypothetical substance B, the combination of which with an amino-acid governs the rate of protein synthesis, is different for each amino-acid. These experiments do not tell what B is. Among the possibilities are that B is the locus of the amino-acid on the template or B is some specific carrier of the amino-acid.

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Inhibition of Dextransucrase by Excess Substrate

HEHRE[1], working with the enzyme dextransucrase, showed that a plot of initial velocity v against substrate concentration deviated from linearity above a sucrose concentration of 200 mM. This was tentatively explained on the basis of a decrease in concentration of water in the stronger sucrose solutions.

Our interest in this polysaccharide-synthesizing enzyme[2] prompted us to examine this phenomenon more closely. Using fructose production as a measure of enzyme activity, the conversion of sucrose to dextran was examined in substrate concentrations ranging from 20 mM to 1,000 mM. The details of the enzyme preparation and the analytical procedure have been reported elsewhere[2]. A sucrose solution (1 ml.) containing 0·1 M acetic acid–sodium acetate buffer at pH 5·0 was added to the enzyme solution (0·2 ml.) and the mixture incubated at 30° C. in a constant-temperature water-bath for half an hour. The reaction was quenched at the conclusion of this time by the addition of 0·1 N sodium hydroxide (1 ml.) and the reducing sugars determined[3,4]. The results of these experiments are shown in Fig. 1.

Assuming that excess substrate inhibits this particular reaction, the following mechanism may be postulated[5] :

$$E + S \underset{k_2}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_3} E + P \tag{1}$$

$$ES + S \underset{k_5}{\overset{k_4}{\rightleftharpoons}} SES \tag{2}$$

$$K_{ss} = [ES][S]/[SES] \tag{3}$$

where E = enzyme, P = products, S = substrate, SES = inactive complex, K_{ss} = dissociation constant for inactive complex.

The steady-state treatment of the above mechanism yields the following rate equation :

$$\frac{S}{v} = \frac{K_m}{V} + \frac{S}{V} + \frac{S^2}{VK_{ss}} \tag{4}$$

where K_m = Michaelis constant, V = maximum initial velocity. Differentiating (4) with respect to S yields a linear relationship (5) between S and the tangent of the curve resulting from a plot of S/v against S.

$$\frac{\mathrm{d}(S/v)}{\mathrm{d}S} = \frac{1}{V} + \frac{2S}{VK_{ss}} \tag{5}$$

The values for K_m, K_{ss} and V may be readily calculated from the slope intercept relationships obtained from the plots of equations (4) and (5). Performing the necessary arithmetic we obtain the following values: K_m = 35 mM, V = 0·35 mgm. fructose/0·2 ml. enzyme/half an hour and K_{ss} = 3,900 mM. It will be noticed that the first two values agree closely with the values obtained previously[2] for these two constants. Substituting the derived figures for the three constants into equation (4) a calculated value for the initial velocity v may be obtained. This is shown by the smooth curve in Fig. 1.

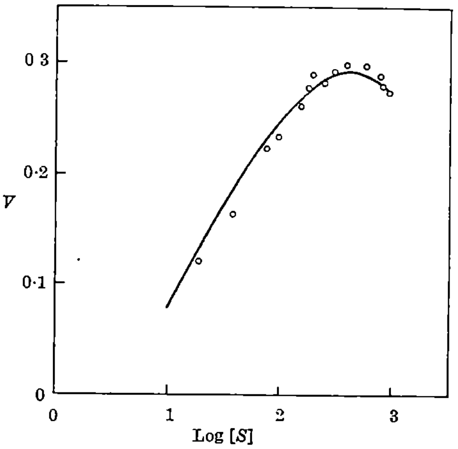

Fig. 1. Plot of initial velocity (mgm. fructose/0·2 ml. enzyme/½ hr.) against the logarithm of substrate concentration. The open circles represent experimental points while the smooth curve was calculated from equation (4)

The close correspondence between the experimental and the calculated curve tends to substantiate the original assumption that it is excess substrate which inhibits this particular enzyme. From the theory of the two-step reaction systems[5] another point of interest may be derived from the present work. If the enzyme has the same affinity for both the first and second substrate molecules, the value of the quotient $K_{ss}/4K_m$ will be unity. If the affinity is greater for the first substrate molecule, the ratio will be greater than unity. It is obvious that the second alternative holds in the present case, namely, that dextransucrase has a much greater affinity for the first substrate molecule than it does for the second.

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Determination of the Mass Thickness of Cell Membranes from their Electron Micrographs

In this communication, we give values of the mass thicknesses of the cell membranes of *Bacterium coli*, human red blood corpuscle and *Leishmania donovani* estimated as follows.

Purified normal cells in each case were disrupted by chemical means to remove the cellular contents. The cell membranes, after separation, were collected on collodion-coated grids, and after drying only collapsed cell membranes remained. These were then examined with a Siemens 'Elmiskop I' electron microscope at 60 kV. with an objective aperture angle of $\sim 10^{-2}$ radian, and afterwards photographed on Ilford Process plates. After due processing of the plates, the photographic densities D_t and D_0 in the imaged region and in the background respectively were measured with a densitometer. For the photographic negative used, it was found from a previous experiment that the γ value under the above working and processing conditions was 2·8 within the photographic density-range 1·5–3·0.

Since in a photographic negative containing both the specimen and the supporting film regions, the time of exposure was the same, it followed that the respective measured densities D_0 and D_t were related to the corresponding electron intensities by the relation:

$$D_0 - D_t = 2{\cdot}8 \log_{10} (I_0/I_t) \qquad (1)$$

It is known from the electron scattering formula of Liesegang[1] that in the electron microscope the image intensity I_t is related to the object mass thickness ρx by the expression,

$$I_t = I_0 \exp\left(-\frac{N_A}{\pi} \cdot \frac{Z^{4/3}}{A} \cdot \lambda^2 \cdot \rho x\right) \qquad (2)$$

where the symbols have their usual meanings.

It has been shown by Zeitler and Bahr[2] that for various biological materials equation (2) can be written as:

$$I_t/I_0 = \exp(-4{\cdot}43 \times 10^4 \rho x) \qquad (3)$$

for 60 kV. electrons. Combining equations (1) and (3), ρx is given by:

$$\rho x = \frac{D_0 - D_t}{2{\cdot}8} \times 52{\cdot}4 \ \mu\text{gm.cm.}^{-2} \qquad (4)$$

The relevant data and the corresponding mass thicknesses of the cell membranes are given in Table 1.

Table 1. MASS THICKNESS OF CELL MEMBRANES

Specimen	Photographic density		Mass thickness of the cell membrane ρx (μgm.cm.$^{-2}$)	Computed thickness assuming $\rho = 1$
	D_t	D_0		
(Cell membrane) *Bacterium coli*	2·29	2·49	1·86	186 A.
Human red blood cells	1·58	1·85	2·51	251 A.
L. donovani	2·54	2·88	3·16	316 A.

The mass thickness of the cell membrane, as calculated from equation (4) with the help of the data in columns (2) and (3) above, is really the density multiplied by twice the membrane thickness, as the two membranes collapse together and provide the photographic density D_t. So the mass thickness of a single membrane of a cell would be half that of the value estimated from equation (4) and has been recorded in column (4).

Assuming the value of unity for ρ, the density of the material composing the membranes, the respective membrane thicknesses are as recorded in column 5. These values are to be compared with the thickness values of (100–150 A.), (120–300 A.) and 250 A. respectively reported by other workers[3-5].

Thanks are due to Prof. N. N. Das Gupta for his kind help and interest in this work and to Mrs. J. Chakraborty, and Messrs. S. B. Bhattacharjee and K. N. Bhattacharjee for their help in preparation of the specimens. Thanks are also due to the Ministry of Scientific Research and Cultural Affairs, Government of India, for financial assistance.

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A New Method of tracking Artificial Earth Satellites

Existing instruments for making precise trajectory observations on artificial Earth satellites generally employ photographic techniques, a good example being the Schmidt–Baker–Nunn cameras of the Smithsonian Astrophysical Observatory. Since the launching of *Sputnik* 2, we have been experimenting with optical tracking by a photo-electric method which appears capable of adequate sensitivity and a precision comparable with that of astronomical observations, and thus high enough for observing the non-secular perturbations of a satellite orbit. The principal

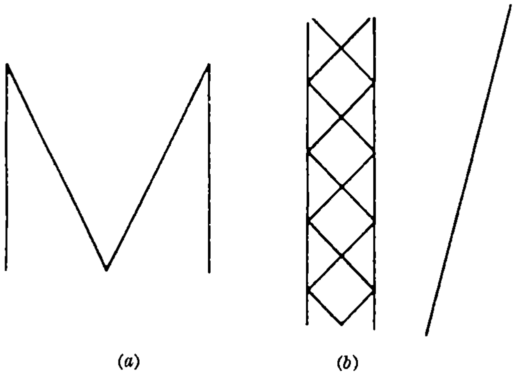

Fig. 1. Slit systems which can be used to determine the line of sight of a satellite: (a) the simplest system which has been used; (b) a version giving greater precision

advantage of the method is the simpler design of the optical system since a long focal length can be used, unlike the photographic method where a short-focus lens is required. The correction of lens aberrations is thereby rendered much easier. A performance in many ways comparable with the Schmidt–Baker–Nunn camera has been obtained with a lens having a 5-in. diameter aperture and 14-in. focal length.

The method used is as follows: A system of slits is placed in the focal plane of a lens and, behind them, a photo-multiplier. As the satellite, which must be sunlit, moves across the sky, its image moves across the slits and produces a series of pulses. These enable the position of the track in the sky to be determined if the orientation of the lens axis is also known. This can be found by stellar observations. If the azimuth and elevation of the satellite are expressed as power series in time of the nth degree, the minimum number of slits required is $(2n + 2)$. We have so far mainly used what is perhaps the simplest system possible, of the form shown in Fig. 1*a*. It is here necessary to assume that the apparent path of the satellite is a straight line, the satellite moving with constant angular velocity. The azimuth and elevation of two points on the track, spaced at a distance equal to the angular width of the slit system, are then found. The estimate of the angular velocity so obtained is of relatively poor precision unless widely-spaced slits are used, so the best method of making accurate measurements of angular velocity is to make a number of observations over a large part of the trajectory. The error caused by the assumption of a linear track can be reduced by making the slit system sufficiently narrow, but in order to cover a reasonably large part of the sky a rather more complicated slit system such as that shown in Fig. 1*b* must then be used. The extra slit is in this case used to identify the element of the system over which the track has passed.

The limiting satellite magnitude which can be detected is determined by the shot noise in the photomultiplier due to steady illumination of the slits by skylight and starlight, which generally exceeds the noise due to the dark current of the cell. When the bandwidth of the recording system is an optimum, the signal-to-noise ratio is proportional to $(\sigma A/B\omega\theta)^{1/2}$, where σ is the photocathode sensitivity, A the lens aperture area, B the sky brightness, ω the angular velocity of the satellite and θ the length of the slits. The width of the slits does not appear in this expression, so that the accuracy and sensitivity of the system can be adjusted independently.

The much lower angular velocity of stars makes possible discrimination against the signals they produce. The image of star or satellite is made just to fill the width of the slits, by defocusing if necessary, and the differentiating time constants of the recording system are then so chosen as to discriminate strongly against the slowly rising pulses produced by stars.

We have so far used two different telescopes, with apertures of 2 and 5 in. The peak noise-level of the larger instrument, produced by the midnight sky in July, is equal to the signal from a 10th magnitude object. Each instrument has a precision of about 15 sec. of arc, but different methods of calibration with stars are used. On the 2-in. telescope, the photocell must be removed and replaced by a photographic film. The slits are so constructed that a large area of sky around them can be photographed to obtain the orientation of the axis. The other telescope is fitted with accurate scales of azimuth and elevation which are calibrated by allowing stars to trail across the slits (the time constants of the recording system being adjusted to allow this). The accuracy of the first instrument is limited by the optical system, that of the second, on which the centre of the image can be located to 2 sec. of arc, by the mechanical construction.

No reason is apparent why a suitably designed optical system should not give a very substantially higher accuracy than these telescopes. A rather larger aperture is also easily obtained and would give a useful improvement in sensitivity. We now propose to build such equipment, and to exploit more fully the potentialities of this method.

The signal-to-noise ratios we have observed indicate that objects as bright as *Sputnik* 3 could be detected by this method during the daytime, using a field of view of about ½°. We have not yet attempted to do this.

A record obtained on July 23 from the rocket of *Sputnik* 3 with the 5-in. telescope is reproduced in Fig. 2. Five successive passages of the satellite across the slits were recorded, the telescope having been moved progressively across the sky. There are some additional pulses on the record which occurred when the telescope was being moved. The slit system was a simplified form of that shown in Fig. 1*b*, so that a fifth pulse occurs on some sets. The marked variation of brilliance of the satellite is clearly shown. The timing marks are 1 c./s. pulses from a chronometer. This record can be measured to an accuracy equivalent to 1 min. of arc. During this phase of the work we used a low recorder speed with a consequent loss of timing accuracy. We are now using recorder speeds more consonant with the accuracy of the optical system. Figs. 3*a* and 3*b* show the two telescopes.

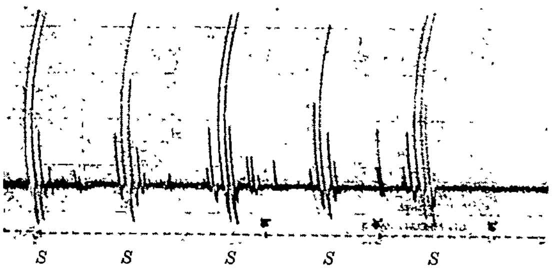

Fig. 2. A record of *Sputnik* 3 rocket. The groups of pulses marked *S* are due to the satellite, the remainder having been produced as the telescope was moved

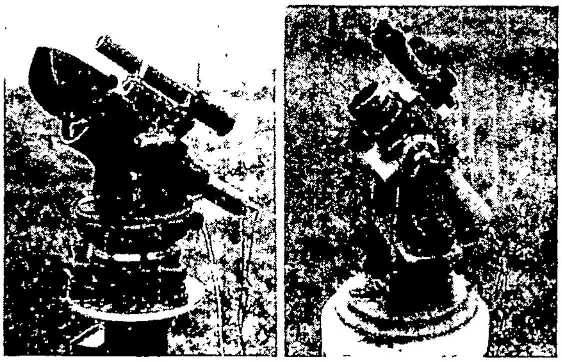
(a) (b)

Fig. 3. The two tracking telescopes: (a) 5 in. and (b) 2 in. aperture, respectively

The equipment has been operated on a site at the B.B.C. Receiving Station, Tatsfield. We are greatly indebted to the B.B.C. for the many facilities which they have afforded us. We gratefully acknowledge also a grant from the Royal Society.

This work could not have been carried out without the assistance of Drs. R. L. F. Boyd and R. F. Stebbings, and Messrs. K. Maxwell and A. Thompson in operating the telescopes.

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Scale Height of the Upper Atmosphere

Several formulæ have been published recently for calculating the effect of air resistance on orbits of artificial Earth satellites. The latest and most complete are by King-Hele and Leslie[1]. Nearly all these formulæ are valid over a somewhat limited range of eccentricity and are based on a spherical Earth. The effect of ellipticity is by no means negligible and can be corrected for without much additional complication.

If the scale height of a homogeneous isothermal atmosphere is H at a distance r from the centre of the Earth, then r^2/H is practically constant and independent of latitude.

If R is the Earth's local radius then:

$$\rho = \rho_0 \exp\left\{-\frac{r^2}{H}\left(\frac{1}{R} - \frac{1}{r}\right)\right\} \tag{1}$$

If e is the eccentricity of a satellite orbit, r_p is the radius at perigee, θ the anomaly, i the inclination, φ the angle from apex to perigee and ε the Earth's ellipticity, then:

$$r = \frac{r_p\,(1+e)}{1 + e\cos\theta} \tag{2}$$

$$R_p = R_{\text{max.}}\,(1 - \varepsilon\sin^2 i\cos^2\varphi) \tag{3}$$

$$R - R_p = R\varepsilon\sin^2 i\sin\theta\sin(2\varphi + \theta) \tag{4}$$

Let $\dfrac{R}{H_0}\,\varepsilon\sin^2 i = \beta$, then omitting terms which average out around the orbit:

$$\rho = \rho_p \exp\left\{-\frac{e}{1+e}\cdot\frac{r_p}{H_p}\,(1-\cos\theta)\right\} \times \left\{1 + \left(\beta\cos 2\varphi + \frac{\beta^2}{2}\sin^2 2\varphi\right)\sin^2\theta + \left(\frac{\beta^2}{2}\cos 4\varphi + \frac{\beta^3}{2}\sin^2 2\varphi\cos 2\varphi\right)\sin^4\theta + \ldots\right\} \tag{5}$$

If the eccentricity is not too small, practically all the retardation occurs near perigee, $\sin^4\theta$ is negligible and $\sin^2\theta = 2\,(1-\cos\theta)$, so that:

$$\rho = \rho_p \exp\left\{\left(2\beta\cos 2\varphi + \beta^2\sin^2 2\varphi - \frac{e}{1+e}\cdot\frac{r_p}{H_p}\right)\times(1-\cos\theta)\right\} = \rho_p\exp\{-\psi\,(1-\cos\theta)\} \tag{6}$$

Let $\psi = \dfrac{e}{1+e}\cdot\dfrac{r_p}{h}$, where h is the adjusted scale height.

If Ω is the satellite's angular momentum, C its resistance coefficient, m its mass per unit frontal area and S its distance of travel, then for a non-rotating Earth:

$$\frac{d(\log\Omega)}{dS} = -\frac{C\rho}{2m} \tag{7}$$

The Earth's rotation reduces the airspeed by an almost constant fraction which can be allowed for by a change in ρ_0.

Also

$$\frac{de}{d(\log\Omega)} = 2\,(\cos\theta + e) \tag{8}$$

$$\frac{dr_p}{d(\log\Omega)} = \frac{2r_p}{1+e}\,(1-\cos\theta) \tag{9}$$

$$\frac{dS}{d\theta} = \frac{r_p\,(1+e)}{(1+e\cos\theta)^2}\sqrt{(1 + 2e\cos\theta + e^2)}$$

$$= r_p\,(1+e)\left\{1 - e\cos\theta + \frac{e^2}{2}(1+\cos^2\theta) - \frac{e^3}{2}(3\cos\theta - \cos^3\theta) + \ldots\right\}$$

$$= r_p\,(1+e)\times\left\{1 - e^3 - (e-e^2)\cos\theta + \frac{\delta^2e^2}{2} + \frac{3\delta^2e^3}{2} - \frac{\delta^3e^3}{2}\right\} \tag{10}$$

$$\delta = 1 - \cos\theta$$

From (5) it is clear that the mean value of δe in the significant part of the orbit is of the order of $(1+e)\,h/r_p$, which is probably less than 0·01, so that δ^2e^2 will be negligible.

If then e^4 is negligible:

$$\frac{dS}{d\theta} = r_p\,(1+e)\{1 - e^3 - (e-e^2)\cos\theta\} \tag{11}$$

Using (6), (7), (11) and (8) or (9), exact solutions are obtainable for mean values around the orbit:

$$\frac{de}{d\theta} = -\frac{C\rho_p r_p\,(1+e)\,(1-e^2)}{m}\times\left\{\left(1+\frac{h}{r_p}\right)I_1(\psi) + e^2I_0(\psi)\right\}\exp(-\psi) \tag{12}$$

$$\frac{dr_p}{d\theta} = -\frac{C\rho_p r_p^2\,(1+e)\,(1-e^2)}{m}\times\left[I_0(\psi) - \left\{1 + \frac{h}{(1+e)\,r_p}\right\}I_1(\psi)\right]\exp(-\psi) \tag{13}$$

If $\psi > 2$ then, with an error of less than 1·5 per cent if $2 < \psi < 4$ and of 0·5 per cent if $\psi > 4$, we have:

$$\frac{dr_p}{d(\log e)} = \frac{h}{2(1+e)}\left(1 + \frac{2}{3}\cdot\frac{h}{r_p}\right)\times\left(1 + \frac{3}{4\psi} + \frac{3}{4\psi^2} + \frac{3}{2\psi^3}\right) \tag{14}$$

Since h is not constant this must be integrated numerically; however, integration is made easier by the fact that $d(e^2)/d\theta$ varies very little during the life of an artificial satellite.

If $\psi < 2$, the approximate formula (14) becomes very inaccurate and $\sin^2\theta$ can no longer be equated to $2(1 - \cos\theta)$, so that (5) must be used in its full form. The eccentricity, e, however, is so small that it can be omitted from the remainder of the formulæ.

Solutions are easily obtainable in terms of the Bessel functions I_0 and I_1, but they are rather long and only apply to the last few days of a satellite's life.

If the mean temperature between R and r_p falls from equator to poles the ellipticity of the surfaces of constant density will be increased. This can be allowed for by a change in ε.

For a mixture of gases of different molecular weights it is necessary to sum the values of (12) and (13) for the components. Values of H obtained from satellites with different perigee radii may give some information about the change of composition with height.

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Thermo-electric Observations on Grey Selenium

The thermo-electric power of grey selenium has been accorded considerable attention in recent years, and Henisch and Francois[1], among others, have carried out accurate measurements and discussed their results in terms of a simple model. We wish to report some thermo-electric results, obtained in the course of an investigation of the photo-catalytic properties of this modification of selenium, which are at variance both with common experience and with these workers' model.

It seems to be experimentally well established that selenium is almost unique among semiconductors in having a thermo-electric power with a positive temperature coefficient: this can be explained[1] by assuming that the activation energy of the semiconductor is so small that most of the impurity centres are normally ionized. By submitting selenium to repeated vacuum distillations followed by recrystallization, we have prepared spectrographically pure samples, from which a few substantially monocrystalline ingots were grown by the Bridgman technique. Most of the ingots, however, consisted of bundles of large grains all having their c-axis parallel to the growth direction (oriented polycrystals). Thermo-electric power measurements on ingots of both types, extending over many months, yielded results of marked qualitative difference. As shown in Fig. 1, the oriented polycrystal specimen has a thermo-electric power which increases with temperature, and further exhibits hysteresis and secular changes, since the scatter of the points is much worse than the measurement error (of the order of 1 per cent at all but the lowest temperatures). Both these features have been reported to be of common occurrence with monocrystalline as well as with polycrystalline samples[2]. We found, however, that monocrystals showed a thermo-electric power quite independent of temperature, and insensitive to thermal history. The scatter of results below −100° C. is due to the rapidly increasing resistance of the specimen (upwards of 10^{10} ohms), which impaired the precision of the measurement, carried out by means of an integrating potentiometric circuit already described[3].

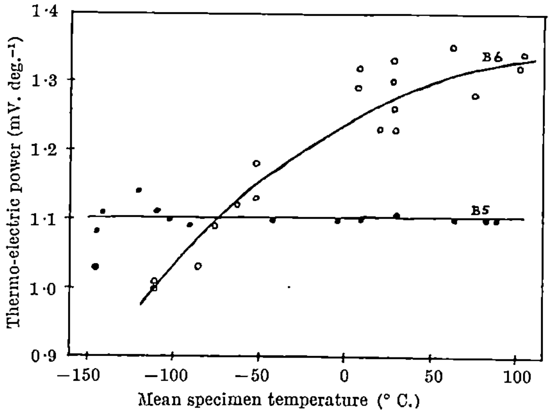

Fig. 1. Thermo-electric power of grey selenium crystals. *B5*, single crystal; *B6*, oriented polycrystal

One of us (J. I. C.) is indebted to the Engineer-in-Chief of the General Post Office for permission to make use of this information.

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New Supersonic Phenomena

Polarized light has been used for determining the propagation of stress waves in solids for some time. We have employed it to study the propagation of stress waves in glass and plastics and have found what we believe to be evidence of new supersonic phenomena. The experimental arrangement follows classical lines, using 'Polaroids' and quarter-wave plates that give circularly polarized light through the transparent sample. For illumination, we used a 1530 *PI* discharge tube (General Radio) with an effective flash duration of 2 μsec. The transparent sample was loaded by exploding small amounts of lead azide with an electric 'bridge'. The timing between the flash and the explosion was achieved by a suitable electric timer which allowed a variation of the delay from zero to 30 μsec. It is well known that shock loading causes a compressional and a shear wave to be propagated in the material, both of which essentially follow the so-called Huygens construction.

However, our 'single shot' tests showed that, far in advance of the compressional wave, which has a speed of propagation of 5,500 m./sec. in glass, dark lines occurred at the far corners of the rectangular specimen at about 45°. These dark lines appear as much as five times as early as the compressional wave could have reached the point. We also investigated 'meeting shots' where two explosive charges at the centres of the short ends of a sample of glass,

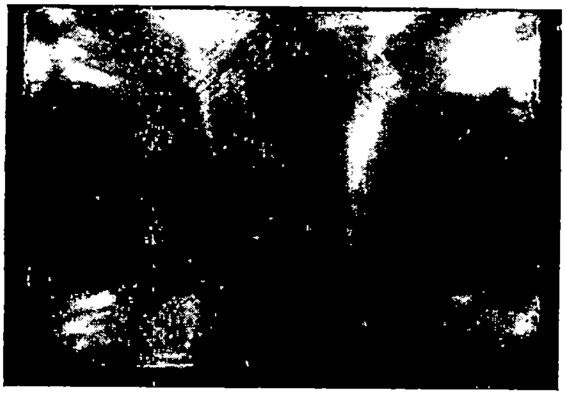

Fig. 1

4 in. × 6 in., were exploded in series. When the delay was such that the compressional waves were propagated about 1 in. into the sample, a very sharp pattern of parallel lines was observed in the centre of the sample much in advance of the compressional wave. Similarly, parallel line patterns were observed near the sides of the sample, as is seen in Fig. 1. The conditions of operation were: 10·6 μsec. after explosion on a glass plate 80/1,000 in. or 2 mm. thick using 13 mgm. lead azide. Similar photographs have been made in colour and have shown that the blue interference patterns have a completely different colour from the reddish-yellow one of the explosion.

Both the 'single shots' and the 'meeting shots' give evidence of phenomena occurring up to about five times faster than the compressional speed of sound, or up to a speed of about 30,000 m./sec. in glass. Similar investigations made on plastics, for example, methylmethacrylate ('Lucite') and *CR*39 resin, showed basically the same phenomena but much less distinctly, apparently damped out. We have investigated the possibilities of experimental errors causing these theoretically unexpected wave phenomena in solids but have not been able to find any. The phenomena photographed are faint as compared with the intensity of the compressional wave; however, they seem to be standing waves, whereas the compressional waves move with the velocity of sound. Therefore, the use of a 2 μsec. flash which gives a blurred picture of the compressional wave results in sharply defined traces of the supersonic pattern. The charge used seems to be an optimum for the detection of the phenomena in glass. The patterns depend on the thickness of the sample: they are sharper with thin plates, their spacing increasing linearly with the thickness.

Experiments using an electrical delay line between the (parallel) charges show a shift of the meeting pattern equivalent to the speed of the compressional wave.

The patterns described are completely different from the 'regular' ones obtained by the Huygens construction and are essentially rectilinear and parallel to the sides of the samples. The phenomena could be caused by a very fast wave propagated on the surfaces of the sample, with the two compressional waves generated interfering to produce the pattern by exciting thickness vibrations of the plate. We have found no evidence that these phenomena move at all. The estimated speeds given above are deduced from observing the phenomena ahead of the compressional wave and are not really measurements of velocities; rather they represent a lower limit for the velocity of propagation of these supersonic phenomena.

I have also observed the formation of cracks in glass progressing with the speed of the compressional wave, and even ahead of it, as compared to the crack propagation speed of $\frac{1}{2}\sqrt{E/\rho}$ generally accepted. The cracks are irregular, occurring apparently at flaws in the sample, again departing from the usual radial cracks in impact loading. These observations tend to confirm the reality of the new phenomenon.

Further details of this work will be reported elsewhere. It is being supported by the Office of Ordnance Research, Duke University, Durham, North Carolina.

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Crystal Structure of β-Wollastonite

β-WOLLASTONITE ($CaSiO_3$) comprises both triclinic wollastonite and monoclinic parawollastonite[1]. These forms are not easily distinguishable except by single-crystal X-ray work, since they differ only in the reflexions with k odd, and these are always weak. A new type of infinite-chain silicate structure has recently been proposed[2] for β-wollastonite from X-ray crystallographic work on projections. The three-dimensional work on parawollastonite from Crestmore, California, which is reported here confirms this type-structure.

The cell parameters of parawollastonite are: $a = 15{\cdot}417 \pm 0{\cdot}004$ A., $b = 7{\cdot}321 \pm 0{\cdot}002$ A., $c = 7{\cdot}066 \pm 0{\cdot}002$ A., $\beta = 95° \; 24' \pm 3'$, $G = 2{\cdot}922$, $Z = 11{\cdot}95$ formula units. The systematic absences are: in hkl, $(2h + k) = (4n + 2)$, which can only apply to terms with k even, and in $0k0$, $k = (2n + 1)$. The space group is $P2_1$, with $6CaSiO_3$ in the asymmetric unit of half the cell. The absence in hkl implies further symmetry, in that there must be equivalent, non-lattice, points at 0,0,0; $\frac{1}{2}, \frac{1}{4}, 0$. The positions of equivalent atoms are thus $(0, 0, 0; \frac{1}{2}, \frac{1}{4}, 0) + x, y, z; \; \bar{x}, \frac{1}{2} + y, \bar{z}$; so that only three units of $CaSiO_3$ are crystallographically independent. No centre of symmetry can be assumed; physical tests for this were inconclusive.

The hkl reflexions with k even are relatively strong, which implies a concentration of atoms about the planes $(2n + 1)b/8$. If these planes have limited mirror symmetry[3], the space group becomes the centrosymmetric $P2_1/a$. After preliminary work on a chain structure assuming this space group, on which refinement was not satisfactory, atoms were shifted slightly to give a non-centrosymmetrical structure on which refinement is progressing well. A three-dimensional Fourier synthesis with more than 1,300 observed reflexions has been computed, on which there were no unidentifiable peaks. The [001] projection of the resulting structure is shown in Fig. 1. The atomic maxima on this Fourier synthesis were close to the atomic positions used in the calculation of phases; the directions of the shifts indicate no tendency to return to a centrosymmetric structure.

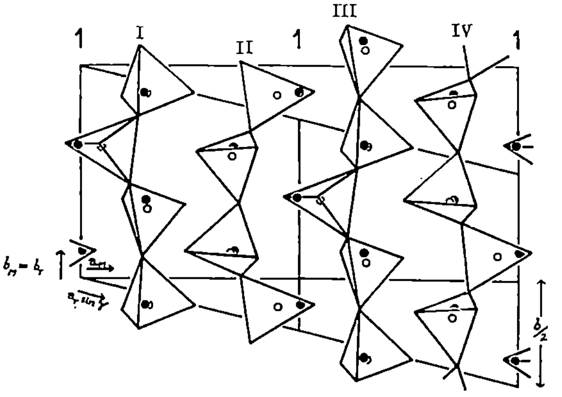

Fig. 1. Parawollastonite structure projected down [001]. ●, calcium atoms; ○, silicon atoms; oxygen atoms at apices of tetrahedra. Axes of monoclinic cell have subscript M, of outlined triclinic cells subscript T

The parawollastonite structure has infinite chains of silicon tetrahedra parallel to the b-axis, as is suspected from its fibrous habit. The repeating unit of three tetrahedra in the chain consists of a pair of tetrahedra joined apex to apex, as in the Si_2O_7 group[4], alternating with a single tetrahedron with one edge parallel to the chain direction. The calcium co-ordination is irregular, though all calcium atoms are co-planar with four near oxygen O^{1-} atoms and have distorted octahedral co-ordination. The atom almost on the screw diad axis has seven oxygen atoms within 2·6 A. of it, one of which is already bonded to two silicon atoms. The other two calcium atoms have almost identical environments. At one apex of the octahedron is an oxygen O^{0-} already bonded to two silicon atoms; at the opposite apex is an oxygen O^{1-} bonded only to one silicon atom. In these octahedra there are two oxygen O^{1-} atoms bonded only to two calcium atoms, instead of three, and to one silicon atom. Pauling's rules are thus satisfied by the addition of charges from the six oxygens around Ca^{2+} of $(3 \times \frac{1}{3} + 2 \times \frac{1}{2} + 1 \times 0) = 2$.

The close relationship between the β-wollastonites is shown in Fig. 1, where two wollastonite cells have been outlined on the one parawollastonite cell; the c-axes are equal. Chains III and IV are not in the same relative orientation as chains I and II in parawollastonite: the symmetry of wollastonite requires that they should be, which can be achieved by shifting chain IV by $b/2$. Since the difference between parawollastonite and wollastonite depends only on a simple packing modification, the close intergrowth of the two is easily explicable.

This work was undertaken at Birkbeck College, London, on an extra-mural grant to the College from the Building Research Station.

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Tetrahedral Co-ordination in Ni(II)

Two forms of Ni(II) compounds have been recognized for a long time, the green paramagnetic forms and the (yellow) diamagnetic forms. The nature of these has been described in terms of electronic structure by Pauling[1], as a paramagnetic 6-co-ordinate form with two unpaired electrons and a square planar form with hydridized orbitals leading to diamagnetism through electron pairing. The magnetic criterion has been completely satisfactory in differentiating these two. There is another 4-co-ordinate configuration theoretically possible, namely, the tetrahedral, which also would have two unpaired electrons. No obvious criterion presents itself for differentiation of this from the octahedral 6-co-ordinate condition.

There are occasional Ni(II) compounds which are blue, and some of these have been studied magnetically by Lifschitz, Bos and Dijkema[2]. The conclusion of these workers was that these compounds were tetrahedral. More recent reports on this identification of possible tetrahedral Ni(II) compounds have been from workers interested in geometrical properties of organic chelating agents, and from those interested in the ligand field type of explanation of transition element spectra and binding. The detailed calculations carried through on this latter basis have apparently not given any clear assignment by spectral relations or other obvious criterion (for example, Maki[3]).

Low[4] has investigated the paramagnetic resonance and optical spectra of Ni(II) in magnesium oxide (MgO) crystals, with a rigid octahedral symmetry imposed by the crystal structure. From his work, the relatively strong sharp peak of the Ni(II) absorption spectrum which is found normally around 400 mμ is due to a transition $^3F(\Gamma_2)$–$^3P(\Gamma_4)$. The highest of the three ^3F levels into which the free-ion ^3F groundstate is split is Γ_4. In the inversion of levels in changing to tetrahedral field[4, 5], the Γ_2 level as groundstate would be replaced by a Γ_4 level. As this $^3F(\Gamma_4)$ should no longer give a relatively strong transition to the $^3P(\Gamma_4)$ level[6], as did the Γ_2 groundstate, the corresponding 400-mμ absorption peak should vanish.

In studies of the absorption spectra of inorganic salts in non-aqueous media, in which this Laboratory has had an interest, experiments have been performed in tributyl phosphate and in acetone media which bear on this question. In acetone, for example, very dilute solutions of nickelous perchlorate (about 2×10^{-4} M—concentrations are chosen to minimize precipitation of nickelous chloride after addition of chloride) are green, and show the characteristic peak at about 410 mμ. Addition of up to two equivalents of lithium chloride intensifies the peak (as it does those at longer wave-lengths), and shifts it to about 423 mμ. Further additions of chloride, however, while still intensifying the peaks at longer wave-lengths, cause the 425-mμ peak to diminish in intensity, and by a composition with four chlorides per nickel, essentially to vanish. In the intermediate stages there is a suggestion that the peak may be splitting into two. The colour of the solutions is a deep blue, reminiscent of the blue cobalt colour, and the spectra at high chloride ratios (for example, 9 : 1 also somewhat resemble those of $CoCl_4^{2-}$. After some hours or a day, even these dilute solutions tend to deposit nickelous chloride. Similar observations were made in the tributyl phosphate solutions.

If a solvent such as *iso*propyl alcohol is used instead of the above, one gets only intensification of peaks even for anion–nickel ratios greater than two. This holds for both chloride and thiocyanate. It is interesting that study of continuous variations of these solutions shows a maximum apparent complexing of four anions per nickel[7]. This apparent limit might be due to problems of replacing further solvent groups, rather than an indicator of pure 4-co-ordination, as the alcohol is a stronger electron donor than acetone, and tends to maintain the higher co-ordination number of cations[8] (with iodide, co-ordination to six groups per nickel can be seen). It might be added that Ni(II) in fused nitrate salt melts is green, and that a blue colour develops on addition of chloride, with a spectrum similar to that of our blue acetone solutions (D. Gruen, private communication). Small amounts of nickel incorporated into solid Cs_2ZnCl_4 (tetrahedral $ZnCl_4^{2-}$) also show the same blue spectrum.

It is therefore suggested that the blue compounds studied by Lifschitz, Bos and Dijkema[2] were in fact tetrahedral, as is also the chloride (in excess chloride) in acetone and tributyl phosphate. The blue colour arises mainly by disappearance of the 410-mμ peak, as would be predicted from Low's[4] analysis of the levels for the Ni(II) ion in the octahedral crystalline field. One may venture to state the following generalization: paramagnetic nickelous compounds which are the normal green colour, or the spectra of which show the equivalent of the 410-mμ absorption peak of the green form, are to be presumed to be 6-co-ordinate, or at least to possess the electronic structure characteristic of the 6-co-ordinate state. Paramagnetic compounds of Ni(II) which fail to show this absorption peak (and which may be blue, if the colour is not masked by the ligand) are presumably tetrahedral, or have the equivalent electronic structure. Diamagnetic compounds have, of course, the square planar form.

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Production of Methane from Carbon

The recent work of Blackwood and McGrory[1] has shown that methane is formed when carbon, in the form of coconut char, is allowed to react with steam under pressure. The rate of formation of methane is a linear function of the steam pressure and appeared to be independent of the partial pressure of hydrogen when the latter is small. A similar study[2] of the reaction of hydrogen and carbon under pressure at temperatures of 650–950° C. has shown that the rate of formation of methane is a linear function of the hydrogen pressure and that the addition of small amounts of steam to the atmosphere of hydrogen has no apparent effect on the rate of formation of methane. It is suggested that the mechanism of methane formation is the same. The rate of formation of methane, for the same carbon, prepared at 950° C., with 30 atm. of steam at 870° C., is 16×10^{-5} gm.mol./min./gm. carbon, and with hydrogen under the same conditions is 10×10^{-5} gm.mol./min./gm. carbon. The rate varies with the temperature of preparation of the carbon and lower-temperature carbons are more reactive, reaching a maximum reactivity to hydrogen when prepared at about 750° C.

Similar results were obtained by Goring *et al.*[3] in the gasification of 'Disco' char with a steam–hydrogen mixture at 870° C., their results showing that there is no significant change in the rate of formation of methane at a given temperature and pressure when the reactant gases are mixtures of steam and hydrogen in the ratios 50/50, 75/25 and 90/10. Their gasification-rate at 870° C. and 30 atm. pressure was approximately 33×10^{-5} gm.mol./min./gm. carbon, and later experiments in the same apparatus with similar char[4], using hydrogen only as the reactant gas, gave a rate of 40×10^{-5} gm.mol./min./gm. carbon. Wood charcoal, prepared at 870° C. from *Eucalyptus marginata*, when made to react with hydrogen under the same conditions of temperature and pressure, gave[2] a rate of formation of methane of approximately 45×10^{-5} gm. mol./min./gm. carbon.

It has been suggested[1] that the carbon–steam reaction is controlled by oxygen groups attached to the carbon and that the methane produced is formed by reaction of steam with adsorbed hydrogen, liberating methane and carbon monoxide. The formation of methane by reaction of hydrogen with carbon is believed to be controlled by oxygen groups, such as chromene or benzpyran, in the carbon structure[2], and it now appears that these may be effective in controlling methane production in both the carbon–steam and carbon–hydrogen reactions.

The formation of methane during the carbon–steam reaction is important technically since it results in a reduced heat requirement for the gasification of carbon with steam due to the exothermic nature of the reaction producing methane.

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Paper as a Carrier of Chromium Sesquioxide

Chromium sesquioxide (Cr_2O_3) is widely used for estimating feed digestibility[1] or fæces output[2] by ruminants, but such estimates may be subject to considerable errors because the concentration of this marker in fæces normally shows considerable diurnal variations even after prolonged regular administration. These variations are particularly obtrusive with grazing animals where the chromium sesquioxide, in

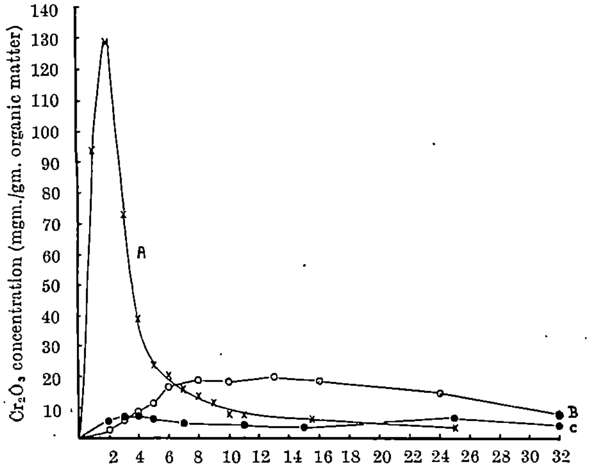

Fig. 1. Concentrations of chromium sesquioxide expressed as mgm./gm. organic matter in digesta drawn from the duodenum of a sheep following the administration of single doses of chromium sesquioxide: *A*, as the powder in a gelatin capsule; *B*, in paper; *C*, in plaster of Paris

this case used for estimating the output of fæces, is usually administered in concentrated powder form in gelatin capsules once or twice daily, and they probably arise primarily from an imperfect mixing of the oxide with digesta in the reticulo-rumen[3,4]. This view is supported by unpublished observations (by J. F. D. Greenhalgh) on the concentrations of chromium sesquioxide in the organic matter of digesta obtained from the duodenum of a sheep permanently cannulated at this point. As the variations in concentration during a period of regular dosing showed the same pattern and were greater than those found in the fæces, it was decided to study in a comparably cannulated sheep the passage of single doses of oxide powder, each given in a gelatin capsule and in amount large enough to give measurable concentrations over a considerable period of time. Samples of digesta were drawn from the duodenum at intervals beginning 1 hr. after dosing. Results from a typical run where 8 gm. were given are shown in Fig. 1 (line *A*) and indicate that a large part of the dose had passed from the stomachs within 4 hr. of administration. The probable explanation is that the capsule container dissolved quickly in the anterior rumen or reticulum[3] and that local concentrations of chromium sesquioxide in these regions[4] were rapidly transferred through the reticulo-omasal orifice.

Properly to fulfil its function as a marker, chromium sesquioxide should be cleared from the reticulo-rumen at a rate as nearly as possible equivalent to that of the food dry matter, or any of its constituents under study. Since this condition does not appear to be met by dosing with capsules containing loose oxide, some method of obtaining a slower and more regular release of chromium sesquioxide into digesta appears desirable. An attempt to do this has been made by incorporating the oxide in paper. A small quantity of paper was made by beating chromium sesquioxide in a 3 per cent stock (that is, 97 per cent water) of fully bleached sulphite wood pulp to which was added aluminium sulphate (paper-makers' alum) at 1 per cent of the dry matter. With the method employed it was found possible to obtain a paper containing 20–30 per cent chromium sesquioxide in the dry matter. It was found at this stage that Edin[5] had already suggested the use of a material termed 'chrome-cellulose' for determining the digestibility of rations consisting wholly of roughage. This material, resembling blotting paper, was prepared from a mixture of chromium sesquioxide and paper pulp, but apparently aluminium sulphate was not added. The 'chrome-cellulose' was cut into small strips and mixed with the chopped fodder, but it does not appear to have been tested or used to any large extent. In our experiments, which were concerned primarily with the development of a technique for estimating the output of fæces by grazing animals, the required amount of dry sheet, containing approximately 8 gm. chromium sesquioxide, was cased in gelatin capsules for dosing. It was tested by the rapid method afforded by the examination of digesta passing through the duodenum and one set of results is shown by line *B* in Fig. 1. There was no sign of a rapid passage of chromium sesquioxide through the stomachs; instead concentrations of the oxide steadily increased for 8 hr. after dosing and then remained at approximately the same level for at least a further 8 hr. before slowly declining.

A 'slow-release capsule' devised by Pigden and Brisson[6], which is claimed to reduce variations in concentrations of chromium sesquioxide in fæces, has also been tested. This capsule consisted of equal parts of chromium sesquioxide and plaster of Paris and was cast in a gelatin capsule. Its administration gave the results shown by line *C* in Fig. 1. Again there was no sign of a rapid passage of the oxide, and concentrations remained at approximately the level reached 2 hr. after administration for at least a further 40 hr.

Both methods of administration, in paper or in plaster of Paris, appear to be superior to the administration of the oxide in powder form, but it is believed that chromium sesquioxide paper possesses very considerable advantages. It was found by microscopic examination, using polarized light, that the effect of the aluminium sulphate was to attach the individual oxide particles to the cellulose fibres of the paper so that relatively few free particles were to be found after agitation in water. In addition a large proportion of the oxide appeared still to be attached to partially digested cellulose fibres and closely associated with organic debris in the duodenum. In this respect chromium sesquioxide is equivalent to a naturally occurring marker such as lignin, but possibly without the chief disadvantage of the latter, which appears to be the slower digestion and rate of passage through the alimentary tract of those fractions of the feed containing lignin in greatest concentration[7]. On the other hand, neither the oxide from the ordinary capsule nor that derived from the plaster of Paris capsule showed any marked degree of association with organic matter.

It is considered that the general pattern of the passage of chromium sesquioxide derived from the digestion of the paper, illustrated in Fig. 1, might more nearly approach that of the products of digestion of the food than the passage of the oxide derived from the slow erosion of a mineral matrix although, as has been pointed out elsewhere[4], it is unlikely that any marker can exactly parallel the behaviour of 'dry matter' as such in the gut.

Work is in progress to determine the optimum composition of chromium sesquioxide paper and to discover the pattern of excretion in fæces.

We thank Dr. P. Hobson of the Rowett Research Institute for carrying out the microscopic examinations. One of us (J. F. D. G.) is in receipt of a Drummond Junior Fellowship for Research in Nutrition.

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The Problem of Negative Anharmonicity and the Nature of the Hydrogen Bond in Potassium Hydrogen Fluoride

There are many short hydrogen bonds which have been claimed to be symmetrical, but it is only in the case of potassium hydrogen fluoride that all the experimental evidence indicates that the proton is central. Yet in this substance there are still some problems to be cleared up, one of them being the hypothetical divergence of the protonic vibrational levels. Besides, as will be shown, the experimental results, which were thought to be explainable only in terms of a symmetrical model, may be explained in another way.

Cote and Thompson[1] explained the whole spectrum of the hydrogen fluoride ion between 1,225 cm.$^{-1}$ and 6,196 cm.$^{-1}$ in terms of the selection rules which would be expected for a linear symmetrical structure ($D_{\infty h}$). They found an apparently large negative anharmonic coefficient for the overtone and combination bands of the asymmetric stretching vibration frequency. Following a suggestion of Pitzer and Westrum[2], they explained this divergence of the protonic vibrational levels by assuming a fourth-power potential field: $V(x) \propto x^4$.

However, it can be generally shown that for fields where the potential energy varies for small displacements as the nth power of the displacement (n being a positive number), the isotopic ratio becomes $\nu_H/\nu_D = (m_D/m_H)^{n/n+2}$. In the special case of harmonic forces, n is 2, and $\nu_H/\nu_D = \sqrt{2}$. In the case of a fourth-power potential field[3], the isotopic ratio ν_H/ν_D should be greater than $\sqrt{2}$ (say, 1·59), whereas it actually is 1,450/1,046 = 1·387.

In view of this controversy the question arises whether the divergence of the vibrational levels is due to a false assignment of combinations and overtones. On the other hand, if this divergence of vibrational levels is real, it could be explained by a quite different mechanism, namely, by assuming that hydrogen fluoride represents an intermediate case between a symmetrical oscillator and an oscillator having a double minimum in the potential function. This implies that the barrier is shallow, and that its height is much lower than the lowest energy-level. The vibrational energy-levels would be split into doublets; the splitting would increase with increasing vibrational quantum number until it would be equal to half the separation of successive unperturbed levels. The divergence of the vibrational levels would be more pronounced the higher the potential barrier.

In view of this possibility, we decided to reanalyse all arguments leading to the assumption of symmetrical hydrogen bonding in hydrogen fluoride.

Proton nuclear magnetic resonance measurements[4] and neutron diffraction[5] showed that the equilibrium position of the proton lay within ± 0·06 A. and ± 0·1 A., respectively, of the centre of the ion axis. This does not exclude the possibility of a small and shallow barrier with $2l$ less than 0·12 A.

Pitzer and Westrum proposed a symmetrical structure on the grounds of the absence of a heat capacity peak in the low-temperature region. But as they point out themselves[6], thermodynamic data could not eliminate the possibility of a potential hill so small that the zero energy-level splitting would be greater than 70 cm.$^{-1}$. The possibility of such a splitting was abandoned in view of spectroscopic arguments, which will be discussed later.

Another argument which seemed to favour the symmetrical structure arose from dielectric constant measurements[7]. The dielectric constant of potassium hydrogen fluoride is low (4·1), and is, moreover, nearly independent of temperature. It was suggested that in the case of a double minimum there would be an orientable dipole and a high temperature-dependent dielectric constant would result. However, it can be shown by quantum-mechanical methods that this argument holds only in the case of a large barrier, and thus does not apply to the present case.

Spectroscopic arguments remain. The assignment of the 1,450 cm.$^{-1}$ band as ν_3 and the 1,222 cm.$^{-1}$ as ν_2 is assured[8] and so no doubling of ν_3 is observed. This fact was supposed to eliminate definitely the possibility of a double minimum potential field, but can be explained as follows: if the barrier is very small, then this may be considered as a case intermediate between a double minimum and a symmetrical single minimum oscillator. Calculations show that the zero energy-level splitting might be as large as 1,450 cm.$^{-1}$. The selection rules for a resonance between two $C_{\infty v}$ structures go over into those for a $D_{\infty h}$ structure. The ν_3 band at 1,450 cm.$^{-1}$ can thus be identified with a $v_{0+} \leftrightarrow v_{0-}$ transition. The $3\nu_3$ band at 5,099 cm.$^{-1}$ may be identified with the $v_{0+} \leftrightarrow v_{1-}$ transition, and as the intensity of the $v_{0-} \leftrightarrow v_{1+}$ transition ($2\nu_3 \leftrightarrow 3\nu_3$) is negligibly small owing to the Boltzmann factor, no second double minimum band can be found. The transition $v_{0+} \leftrightarrow v_{1+}$ ($2\nu_3$) would be forbidden by the selection rules.

Hence, except for the explanation of the hypothetical divergence of the vibrational levels, it is a matter of convenience whether we say that the hydrogen bond in potassium hydrogen fluoride is a symmetrical one or that it represents a limiting case of the double minimum type.

I wish to thank Prof. D. Hadži for stimulating and helpful discussions and Prof. A. Peterlin for reading the manuscript critically.

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Synthesis and Structure of 2,6-Dihalo-Benzenone-Indophenylacetate and Benzenone-Indo-3′,5′-Dihalo-Phenylacetate

Hitherto only one compound has been isolated after the esterification of dihalo-benzenone-indophenol with acetic anhydride; this compound was assumed to be 2,6-dihalo-benzenone-indophenylacetate[1]:

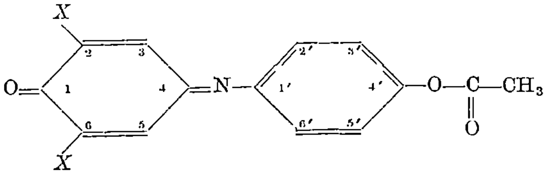


Fig. 1

It is, however, possible to obtain two different acetates—an orange and a red one—from dihalo-benzenone-indophenol, depending on the conditions during the preparation. The two compounds have the same molecular weight and composition, but different colours, melting points, infra-red and ultra-violet spectra and rates of hydrolysis with enzymes.

Red dichloro compound. The red compound was synthesized by a method analogous with Heller's for the preparation of benzenone-indophenylacetate[2]. 5·8 gm. (0·02 mole) of the sodium salt of 2,6-dichlorobenzenone-indophenol in 25 ml. dry ether were heated for 30 min. at 35° C. with 12 gm. acetic anhydride. After cooling, the reaction mixture was put into a beaker containing 500 gm. crushed ice and well stirred for several hours. The ester crystallized; it was filtered off, dried and recrystallized from ether. It formed red crystals, m.p. 99·5°–100·5° C., yield 3·7 gm. (60 per cent), analysis calculated (per cent): C 54·2, H 2·9, N 4·5, Cl 22·9; found: C 54·1, H 2·9, N 4·4, Cl 22·9.

Orange dichloro compound. A modification of a method of Kramer, D. N. (private communication), was used for the preparation of the orange compound. 5·8 gm. (0·02 mole) of the sodium salt of 2,6-dichlorobenzenone-indophenol in 25 ml. dry ether were heated for 15 min. at 35° C. with 2·04 gm. (0·02 mole) acetic anhydride. After cooling, 1 ml. dry pyridine was added. Heating was continued for 15 min. After cooling, the reaction mixture was put in a beaker containing 500 gm. crushed ice and well stirred for several hours. The ester crystallized; it was filtered off, dried and recrystallized from acetone-ether. It formed orange crystals, m.p. 68–69° C., yield 4·3 gm. (70 per cent), analysis calculated (per cent): C 54·2, H 2·9, N 4·5, Cl 22·9; found: C 54·2, H 2·9, N 4·4, Cl 22·9. The corresponding dibromo-compounds were synthesized in the same

Table 1

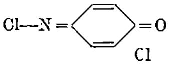
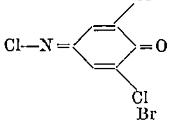
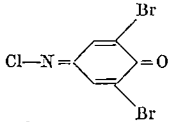
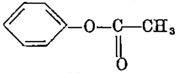
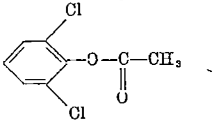
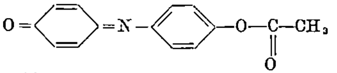
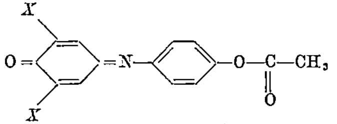
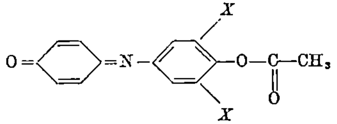
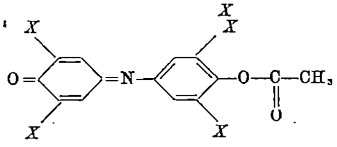
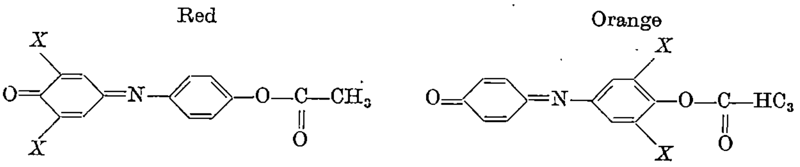
Compound	Wave number (cm.$^{-1}$)		
	Quinonic C=O	Acetoxy C=O	C—O—C
	1637		
	1672		
	1665		
		1765	1190
		1777	1187

Table 2

Compound	Predicted wave number		
	Quinonic C=O	Acetoxy C=O	C—O—C
	*a*	*c*	*e*
	*b*	*c*	*e*
	*a*	*d*	*f*
	*b*	*d*	*f*
	$b > a$ ~ 1650	$d > c$ ~ 1750	$f < e$ ~ 1200



2,6-dihalo-benzenone-indophenylacetate

benzenone-indo-3′,5′-dihalophenylacetate

Fig. 4

way. Paper chromatography showed that each compound could be obtained free from its isomer.

When, however, methods 1 and 2 are applied in the preparation of 2,6 dihalo-benzenone-indo - 3′ 5′-dihalophenylacetate, identical products are obtained. The same holds for the preparation of benzenone-indophenylacetate.

We assume that the formation of the two different compounds is due to mesomerism of the indophenol ion or to tautomerism of the indophenol molecule :

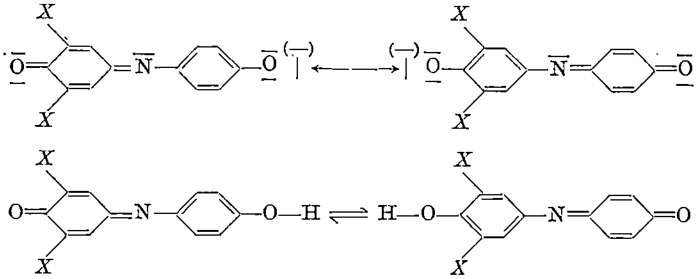
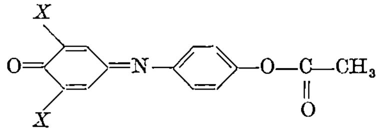


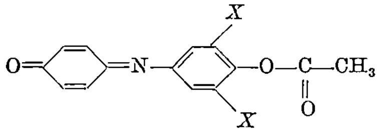
Fig. 2

In that case there are two possibilities for the formation of dihalo esters :



2,6-dihalo-benzenone-indophenylacetate

and



benzenone-indo-3′5′-dihalophenylacetate

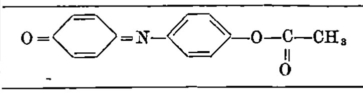
Fig. 3

By studying the infra-red spectra it is possible to determine which of the two structures belongs to the red ester and which to the orange one. Since no groups are characteristic for either of the two structures only frequency shifts due to interactions with surrounding atoms can be taken as a starting point. For this purpose the strong $C=O$ and $C-O-C$ bands were chosen. Generally $C=O$ stretching bands are shifted to higher frequencies when halogen atoms are substituted at a carbon atom next to the $C=O$ group[3]. The influence of halogen atoms in model compounds was studied. The results are shown in Table 1.

From Table 1 the position of the bands can be predicted for the following compounds.

The results obtained with the infra-red spectra of the compounds under consideration are shown in Table 3.

Table 3

Compound	Observed wave number (cm.$^{-1}$)		
	Quinonic $C=O$	Acetoxy $C=O$	$C-O-C$
	1648	1758	1190
Red dichloro compound Red dibromo compound	1665 1662	1753 1755	1189 1195
Orange dichloro compound Orange dibromo compound	1648 1646	1768 1778	1182 1179
Tetrachloro compound Tetrabromo compound	1673 1668	1782 1770	1173 1166

The most characteristic shift is shown by the quinone $C=O$ band. The other shifts can be considered as giving additional evidence for the assignment. Comparison of experimental results with the predicted values leads to the conclusion that the structure of the red and the orange compound is as shown in Fig. 4.

Note added in proof. While this letter was in the press, Dr. D. N. Kramers has informed us that he has obtained results similar to our own.

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Transport of Vitamin A Ester in Rat Serum

It has been established in this laboratory that vitamin A alcohol is associated with the α_1-globulin of rat serum, but not with the low- or high-density lipoproteins and probably also not with the α_1-glycoprotein[1]. In continuation, the absorption of vitamin A alcohol and its transport to the liver as the ester have been studied.

Normal stock rats of the Wistar strain (vitamin A reserves of the liver ± 3,000 I.U./gm.) were put on a vitamin A deficient diet for 48 hr. and were then fed 500 I.U. of vitamin A-2-^{14}C (1·07 mc./mmole) in 0·2 ml. purified peanut oil by stomach tube. Under these conditions no vitamin A ester could be detected in the blood before feeding, but the vitamin A absorbed after administration of the dose should appear in the blood in the esterified form. After administration of the labelled vitamin A, blood samples were collected from the tail at intervals, combusted and counted as barium carbonate in a proportional counter converter (Nuclear Measurements Corporation, type *PCC*-10). The

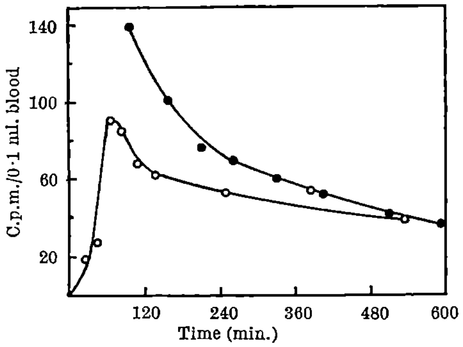

Fig. 1. Appearance of radioactivity in the blood of rats after dose of vitamin A-2-^{14}C (1·07 mc./mmole). ●—●, Rat 1; ○—○, rat 2

radioactivity in the blood reached a maximum after 1½–2 hr. (Fig. 1).

A group of ten stock rats was similarly treated and after 1½ hr. blood was drawn from the dorsal aorta, allowed to clot for 2 hr., and the serum collected and pooled. The lipoproteins were isolated by ultracentrifugal flotation fractionation at solution densities of 1·063 and 1·20 gm./ml. in the Model *E* analytical 'Spinco' ultracentrifuge[2] and directly combusted. The salt concentration of the sedimented proteins was lowered by dialysis and aliquots were afterwards combusted. For vitamin A alcohol and ester estimations, the serum samples were extracted, the alcohol and ester separated by chromatography on alumina[3] and determined by the Carr–Price colour reaction. Samples of the ester and alcohol fraction were also combusted. The carbon dioxide obtained from the combustions was assayed for radioactivity. The results of the analyses are summarized in Tables 1 and 2.

Tables 1 and 2 show that the value obtained by Carr–Price estimation of the vitamin A ester content of serum correlates well with the vitamin A levels, as calculated from radioactivity measurements on either the isolated lipoprotein or vitamin A ester fractions. It further appears that part of the normal serum vitamin A alcohol content of ± 100 I.U./100 ml. was replaced by labelled vitamin A, since the vitamin A alcohol fraction as well as the sedimented proteins, which transport vitamin A alcohol, contained radioactivity.

Table 1. ANALYSIS OF VITAMIN A ALCOHOL AND ESTER FRACTIONS AFTER EXTRACTION FROM SERUM

Description of analysis	I.U./100 ml. serum		
	Ester	Alcohol	Total*
Carr-Price colour reaction after chromatographic separation	127	98†	
Calculated from radioactivity measurements after chromatographic separation	149	27·7	176·7

Table 2. DISTRIBUTION OF VITAMIN A BETWEEN THE PROTEIN FRACTIONS OBTAINED BY ULTRACENTRIFUGAL FLOTATION FRACTIONATION

Description of analysis	I.U./100 ml. serum		
	Lipoprotein fraction	Sedimented proteins	Total*
Calculated from radioactivity measurements on fractions obtained at solution density 1·063 gm./ml.	132·7	38	170·7
Calculated from radioactivity measurements on fractions obtained at solution density 1·20 gm./ml.	130·1	34·6	164·7
Calculated from radioactivity measurements on whole serum			177

* Total refers to labelled ester and alcohol only.
† Consists of both labelled and unlabelled material.

In rat serum, vitamin A ester is therefore transported by the low density lipoproteins. A similar result was recently reported for human plasma[4]. It is interesting to note that the transport of vitamin A ester is similar for man and the rat, despite the species difference.

Mention should be made that the proteins, after extraction of vitamin A ester and alcohol, contained low residual radioactivity. This is probably due to a vitamin A transformation product, since it was found that, on feeding labelled vitamin A to vitamin A deficient rats, the excretion of radioactivity in the urine reached a maximum after 6 hr. and then rapidly decreased (Garbers, C. F., unpublished results).

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Effect of Diet on Imidazole Compounds and Creatine in Chinook Salmon

HALVER[1,2] has recently devised highly purified diets for the Chinook salmon (*Oncorhynchus tshawytscha*), which have been used to determine the amino-acid and vitamin requirements for this species[2,3]. Since the muscle of the salmon contains both free histidine and anserine[4], it was of interest to determine the content of these imidazole compounds in the muscles of histidine-deficient fish. Samples of these and also of control and methionine-deficient salmon were made available to us through the courtesy of John E. Halver, U.S. Fish and Wildlife Service, Cook, Washington. The weight of the histidine and methionine-deficient fish over a ten-week feeding period was relatively constant at 1·8 gm., whereas the control fish increased in weight from 1·8 to 3·3 gm. The skeletal muscles of four fish in each group were combined and were analysed for histidine, 1-methylhistidine, carnosine and anserine by the ion-exchange method of Davey[4,5], and also for creatine and creatinine by the method of Van Pilsum *et al.*[6]. Non-protein nitrogen was determined by micro-kjeldahl. Results are shown in Table 1.

Although histidine is an essential amino-acid for these fish[3], it is present in the muscle in relatively

Table 1. EFFECT OF DIET ON SOME SKELETAL MUSCLE CONSTITUENTS OF CHINOOK SALMON

Sample diet	Histidine	1-Methyl-histidine	Carnosine	Anserine	Non-protein nitrogen (mgm./gm.)	Creatine (mgm./gm.)	Creatinine (mgm./gm.)	Imidazole nitrogen in non-protein nitrogen (per cent)
	(µmoles/gm. wet tissue)							
Control	2·7	1·0	3·3	5·7	3·8	4·9	0·59	17·0
Histidine-deficient	0·3	0·4	0·4	6·1	3·0	6·0	0·25	12·8
Methionine-deficient	0·4	0·6	0·7	8·2	4·2	7·1	0·31	14·0

large amounts and, as expected in the histidine-deficient fish, there was a decrease in its concentration. The change in carnosine concentration indicates that just as in the case of rats, in which carnosine can liberate histidine, it can replace histidine in the diet[7]. The depleted histidine and carnosine in fish deficient in methionine suggest the possible importance of histidine as a one-carbon donor in fish. In all cases the concentration of anserine remained essentially constant. Since histidine, either through 1-methylhistidine or carnosine, is probably the sole source of anserine, it is rather surprising that the organism, on a histidine-deficient diet, maintains its anserine concentration at a high level. It appears that no demethylating system is available here, just as in the case of the chick (Ousterhout, L., Department of Poultry Husbandry, University of California, personal communication), which, on a histidine-deficient diet, maintains a constant anserine level while histidine and carnosine are progressively depleted. The variation in 1-methylhistidine is explained on the basis of anserinase activity, which has previously been suggested to be present in salmon[4] and which has been demonstrated in cod[8].

Choline-deficient fish from a different experiment were also analysed. Although the results cannot be compared directly, the very high creatine concentration of 11·3 mgm./gm. obtained is noteworthy.

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Replacement of Adrenaline and Noradrenaline in the Innervated and Denervated Adrenal Gland of the Rat, following Depletion with Reserpine

IN a previous communication[1] we have shown that reserpine causes a similar percentage loss of adrenaline and noradrenaline from the adrenal gland of the rat. Subsequent recovery of the adrenal amine content was found to be slow. Experiments have now been performed to determine whether this action of reserpine is central or peripheral.

It has been shown by Kroneberg and Schümann[2] that denervation of the adrenal gland of the rat by cutting the spinal cord at the level of *C*6 does not prevent reserpine causing a loss of adrenal catechols. Recently, Mirkin[3] has confirmed this by cutting the splanchnic nerves. However, in both instances the glands have only been assayed for total catechol amines. Here a study has been made of the adrenaline and noradrenaline content of innervated and denervated rat adrenal glands during and subsequent to the depletion caused by reserpine.

The left adrenal glands of male albino rats, weighing 80–100 gm., were denervated by cutting the greater and lesser splanchnic nerve fibres under pentobarbitone sodium anæsthesia—a modification of the method of Vogt[4]. The rats were then left for 3 weeks for the amine content of the glands to return to normal. Test rats were then given 1 mgm./kgm. of reserpine subcutaneously daily for 3 days. Control rats were given the reserpine solvent only. In all experiments test and control groups, each consisting of 10 rats, were killed at 3, 7, 14 and 21 days following the first injection of reserpine, and the adrenal glands removed. The glands were extracted and assayed biologically for adrenaline and noradrenaline, as described earlier[1]. The amine content was expressed in µgm./gland and the points in Fig. 1 represent the percentage difference in amine content between the respective test and control groups.

It can be seen from Fig. 1, derived from the results of three experiments using 300 rats, that there was a similar percentage depletion of adrenaline and noradrenaline, of the order of 40 per cent, in both innervated and denervated glands. The adrenaline then slowly recovered to normal in both groups. However, the noradrenaline content rose to about 200 per cent above the control value at 7 days, falling at 14 days to approximately 80 per cent above, finally returning to normal at 21 days. This occurred in both the innervated and the denervated glands. This similarity between innervated and denervated glands is well seen if the percentages of noradrenaline in the two groups are compared. This is shown at the top of Fig. 1. Before depletion

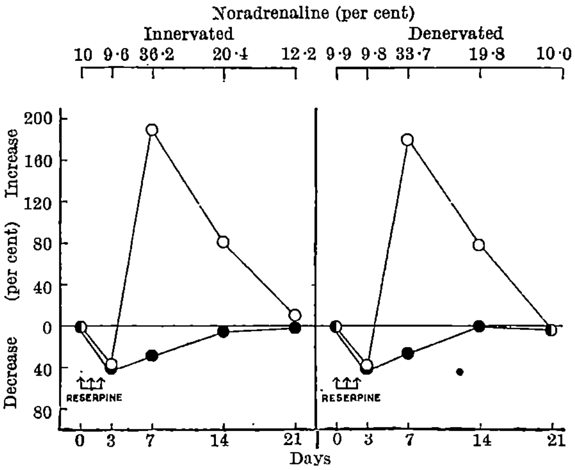

Fig. 1. A composite diagram to show the similarity in the rate of replacement of adrenaline (●) and of noradrenaline (○) in the innervated and denervated adrenal gland of the rat, at various time intervals following depletion with reserpine (1 mgm./kgm.). All results are expressed as percentages of the amine contents of the respective control glands

innervated and denervated glands contain about 10 per cent of noradrenaline. At 3 days, following a similar percentage loss of both adrenaline and noradrenaline, there is still about 10 per cent of noradrenaline present. However, at 7 days both contain about 30 per cent of noradrenaline. This falls to the normal value of 10 per cent by 21 days. Thus no appreciable difference, in either the depletion or replacement of adrenaline and noradrenaline, could be found between innervated and denervated rat adrenal glands. It may be concluded, therefore, that the action of reserpine on the rat adrenal gland is peripheral.

We wish to thank Ciba Laboratories, Ltd., for generous gifts of reserpine.

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Mast Cell and Histamine in Rat Anaphylaxis: the Effect of *Haemophilus pertussis*

It is now well established that mice and rats can be rendered hypersensitive to anaphylaxis by inoculation with *Haemophilus pertussis* vaccine, phase I organisms[1]. Treatment with *H. pertussis* also decreases the resistance of mice and rats to several unrelated factors as well as to histamine[1,2] and serotonin[3]. It is also well known that most of the tissue histamine is located in the mast cells[4] and that in rats and mice these cells are also rich in serotonin[5]. The fact that anaphylaxis in the rat produces mast cell damage and release of histamine into plasma[6] led us to investigate the behaviour of these cells in anaphylaxis of rats treated with *H. pertussis*.

White rats (N.I.M.R. strain) of both sexes and weighing between 200 gm. and 250 gm. were used. Two groups of six animals each were studied. One group was injected with 1 ml. of horse serum subcutaneously and the other received 1 ml. of horse serum by the same route plus 1 ml. of *H. pertussis* vaccine containing 20,000 million organisms intraperitoneally. All the animals were challenged 10 days later by injecting 1 ml. of horse serum intravenously under light ether anæsthesia. 5 min. later, 2 ml. of blood was collected, by puncture of the vena cava, in a syringe containing heparin, and the plasma immediately obtained by centrifugation at 0° C. The animals were then killed by bleeding, and the skin of the snout and lips and the tongue were fixed by injecting through the carotid artery a fixative consisting of 50 per cent aqueous ethanol containing 10 per cent formaldehyde and 5 per cent acetic acid. Fixation was allowed to proceed overnight and frozen sections 50μ thick were stained with toluidine blue. The percentage of mast cells showing granule extrusion was determined by counting 500 cells at a magnification of × 160. The plasma histamine content was assayed on the guinea pig ileum.

Table 1. Plasma Histamine Concentration (μgm./ml.) and Mast Cell Disruption (per cent) in Anaphylaxis of Rats treated and untreated with *H. pertussis*

Rat	Disrupted mast cells		Histamine	
	Untreated	Treated with *H. pertussis*	Untreated	Treated with *H. pertussis*
1	0	67	< 0·03	1·9
2	0	44	< 0·03	0·8
3	0	70	< 0·03	1·8
4	0	85	< 0·03	2·0
5	0	38	< 0·03	1·6
6	0	32	< 0·03	0·8

The results of these experiments are shown in Table 1. As can be seen, inoculation with *H. pertussis* enhances the sensitivity to anaphylaxis so that mast cell disruption (the term disruption is here used to describe mast cells presenting granules scattered around the cell without implying damage to the cell membrane) and appearance of histamine in plasma resulted after injection of antigen. The mechanism by which *H. pertussis* inoculation leads to increased sensitivity to anaphylaxis is not yet understood. The increased sensitivity to histamine produced by *pertussis* vaccine does not explain the increased sensitivity to anaphylaxis since it has been shown that sensitivity to anaphylaxis is still present at a time when there is absence of histamine hypersensitivity[7]. The same seems to be the case with the increased sensitivity to serotonin[7]. Since the response of rats treated with *H. pertussis* to several noxious agents is very similar to that presented by adrenalectomized rats[8], the hypothesis has been proposed that *H. pertussis* acts in some way by causing damage to the adrenal glands. Nevertheless, all attempts to demonstrate a direct effect of *H. pertussis* on the adrenal glands have so far failed[7,9]. It is our experience, however, that after anaphylaxis the number of disrupted mast cells in adrenalectomized rats is also larger than in non-adrenalectomized rats, and that this effect can be prevented by treatment with cortisone. Neither adrenalectomy nor *pertussis* inoculation seems to enhance antibody production[9,10].

A possible explanation for the effect both of adrenalectomy and inoculation with *H. pertussis* would be that the tissue cells are more sensitive to the pharmacologically active materials produced as a consequence of the antigen–antibody reaction. However, the fact that hypersensitivity to anaphylaxis does not necessarily co-exist with hypersensitivity to histamine or serotonin, and our present results showing that *H. pertussis* treatment increases mast cell damage and histamine release in anaphylaxis, suggest that it is the effectiveness of the antigen–antibody reaction in directly causing cell damage that is enhanced. The fact that in rats that have not been treated with *H. pertussis* it is also possible to produce mast cell disruption and release of histamine[6] suggests that the effect of inoculation of *H. pertussis* is not a qualitatively new process. Sensitization by the intraperitoneal route is much more effective in producing mast cell disruption and appearance of histamine in plasma in anaphylaxis than sensitization by the subcutaneous route (for example, in a group of rats sensitized by the intraperitoneal route with alum-precipitated bovine serum albumin the average of disrupted mast cells after shock was 32 per cent, while in a similar group injected by the subcutaneous route only it was 0·4 per cent). This difference does not seem to be due to qualitative or quantitative differences in the antibodies produced, but it may be related to the fact that *H. pertussis* is not effective when injected subcutaneously[10]. A comparative study of the effectiveness of the several routes of sensitization in promoting mast cell disruption and histamine release into plasma in anaphylaxis is in progress.

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Release of Ammonia by Plant Tissues treated with Indole-3-Acetic Acid

In a previous investigation[1], the uptake of amino-acids by plant tissues was followed by means of radioisotopic techniques. When colorimetric techniques were employed in their stead it was found that uptake was masked by the movement of ninhydrin-positive substances from the tissue into the external solution. This observation led to a study of the release of these substances by plant segments. It was observed that when segments of etiolated hypocotyls of *Helianthus annuus* were floated in water or a solution of indole-3-acetic acid (the range tested was $1 \cdot 1 \times 10^{-5} - 1 \cdot 1 \times 10^{-4} M$) ninhydrin-positive substances rapidly made their appearance in the external medium. The concentration of these substances appeared to reach a maximum value within 2 hr.: continued immersion led to no increase in the ninhydrin colour of the medium but, on the contrary, to its gradual diminution. It was further observed that, while indole-3-acetic acid had no clear-cut influence on the initial loss from the tissue, it had a remarkable effect on the amount of ninhydrin-positive material detectable in the medium after about 20 hr. At this stage the concentration in the media containing the auxin was 2–6 times higher than that in the controls (see Table 1).

The behaviour of the ninhydrin-positive substances did not reflect the permeability of the cell membranes to solutes in general. Flame photometry showed that more potassium had been lost to the surrounding fluid after 20 hr. than after 3 hr., and that the loss was greater in the absence than in the presence of auxin. Similarly, after 20 hr., the aldose and ketose concentrations were if anything somewhat higher in the control media. These findings accorded with the visibly better condition of the auxin-treated segments, which were white and turgid with less tendency to turn brown at the cut ends.

Subsequent investigation by means of filter paper chromatography showed that the ninhydrin-positive material present after 20 hr. and so markedly affected by indole-3-acetic acid was not qualitatively identical with that lost from the tissue during the initial period. That lost initially was found to consist principally of glutamine, asparagine, glutamic acid, aspartic acid, leucine and valine. There is evidence that the disappearance of these substances during the course of the experiment was due not only to uptake by the tissue but also to destruction in the medium by enzymes secreted by the tissue. Indole-3-acetic acid had no appreciable effect on this destruction.

Table 1. THE EFFECT OF INDOLE-3-ACETIC ACID ON THE AMOUNT OF NINHYDRIN-POSITIVE MATERIAL DETECTABLE IN THE MEDIUM SURROUNDING SEGMENTS OF SUNFLOWER HYPOCOTYL

Experiment	Indole-3-acetic acid (concentration in μM)	Fresh weight of segments (mgm.)		Ninhydrin-positive material in medium (colorimeter units*)
		Initial	Final	
I. 20 segments in 3 ml. for 18 hr.	0	552	589	15·1
		596	643	18·0
	11	554	703	39·0
		582	760	42·0
II. 110 segments in 15 ml. for 21 hr.	0	3,005	3,315	4·7
		2,985	3,260	2·9
	29	2,816	4,085	22·8
		2,998	4,368	27·9
III. 25 segments in 3 ml. for 16·5 hr. Media buffered at *p*H 5·8 with 0·02 *M* KOH–KH_3PO_4	0	737	838	3·1
		806	866	4·5
	29	743	956	13·0
		808	1,010	12·4

* $2 \cdot 1 \times 10^{-6} M$ ammonium sulphate ≡ 1 unit

The ninhydrin-positive material present after 20-hr. incubation with the segments was only detectable on filter paper if the solution had been acidified prior to concentration and application to the paper. The spot then reacted strongly with Nessler reagent as well as with ninhydrin. The solution before concentration had the following properties: (*a*) it gave an immediate yellow colour with Nessler reagent; (*b*) when mixed with potassium carbonate – potassium bicarbonate buffer, *p*H 9·4, and distilled under reduced pressure in a Parnas apparatus under conditions under which glutamine did not break down, it yielded a distillate which was both Nessler- and ninhydrin-positive; (*c*) when mixed with saturated potassium carbonate and distilled in a Conway microdiffusion apparatus for 3 hr. it yielded an alkaline vapour which could be absorbed in borate buffer. It is thus highly probable that the substance under investigation was ammonia (it will be referred to as such below) though this has not been conclusively proved. It might, for example, be an exceedingly labile substance (considerably more labile than glutamine) readily breaking down to give ammonia. The influence of indole-3-acetic acid could be clearly followed by all of the analytical methods listed under (*a*), (*b*) and (*c*) above.

The work so far described was carried out with seedlings of the variety Pole Star which had been grown in the dark at 24° C. for 7 days. Segments 1 cm. long were cut from the hypocotyls at a distance of 1 cm. below the crook and floated in shallow layers of solution contained in large, stoppered flasks which were shaken gently throughout the experiment. When a change was made to a new batch of seeds from a different supplier, difficulty was at first experienced in reproducing the auxin

Table 2. THE EFFECT OF SUCCINATE AND SUCROSE ON THE AUXIN-STIMULATED ACCUMULATION OF AMMONIA IN MEDIA SURROUNDING SEGMENTS OF SUNFLOWER HYPOCOTYL

(20 segments, cut from the hypocotyls of 8-day-old seedlings, were placed in 2 ml. medium for 18 hr. The media were buffered at *p*H 5·9 with 0·02 *M* potassium hydroxide–potassium dihydrogen phosphate)

Additive (concentration in m*M*)	Indole-3-acetic acid (concentration in μM)	Fresh weight of segments (mgm.)		Ninhydrin-positive material in medium (colorimeter units*)
		Initial	Final	
None	0	612	645	6·4
		635	664	8·6
	29	621	748	27·7
		635	780	22·0
Sodium succinate (4)	0	625	645	4·2
		635	656	3·8
	29	619	748	0·6
		634	756	1·6
Sucrose (44)	9	623	649	3·3
		636	663	4·0
	29	638	763	1·6
		638	774	6·3

* $2 \cdot 1 \times 10^{-6}$ *M* ammonium sulphate ≡ 1 unit.

effect. It was then found that the effect was readily demonstrable either if the plants were allowed to grow for a further three days before removal of the segments, or if the segments themselves were 'aged' by continued immersion in the experimental solutions. These observations suggested that the appearance of ammonia might be due to the utilization of amino-acids as a substrate in respiration (cf. Yemm[2]) and that this process only started after some other substrate had been exhausted, which in the case of the new seeds required more time. Attempts were therefore made in further experiments (carried out with the variety Jupiter) to counter the auxin-stimulated production of ammonia by the provision of an alternative respiratory substrate. Table 2 shows that the addition of either succinate or sucrose prevented the accumulation of ammonia in the media containing the auxin.

If ammonia production was in fact reflecting the respiration of amino-acids it is of importance to note that indole-3-acetic acid did not bring about a stimulation in overall respiration-rate comparable in magnitude with that effected in ammonia production. The oxygen uptake of auxin-treated tissue was at no stage of the experiment more than 25 per cent above that of the controls. The stimulation in ammonia production, on the other hand, was of the order of 200 per cent. This would indicate that in the auxin-treated tissue amino-acids formed a larger proportion of the substrate respired, and may imply a connexion between the action of auxin and the respiration of amino-acids. This suggestion was made previously[3] on entirely different grounds, namely, the higher specific activity of the carbon dioxide evolved by auxin-treated, as compared with control, segments when radioactive glutamic acid was supplied in the external solution. Another possible explanation for the higher proportion of amino-acids apparently respired in the presence of indole-3-acetic acid is that the increased cell-wall synthesis stimulated by the auxin consumes alternative respiratory substrates such as sugars.

The disappearance of the auxin effect in the presence of succinic acid or sucrose does not necessarily indicate, however, that these substances were suppressing the oxidation of amino-acids. They may have provided acceptor molecules for the ammonia produced in processes other than oxidation. It is possible, for example, that the release of ammonia observed in media containing auxin was connected, not with respiration, but with protein synthesis. A preliminary to the latter might be the hydrolysis of glutamine and asparagine, considerable reserves of which are known to be present in this tissue.

The effect of indole-3-acetic acid reported here is not confined to sunflower tissue. It has also been noted in the epicotyls of *Pisum sativum* var. Alaska, though the effect has not yet been investigated further in this case.

This work will be published in detail elsewhere.

I wish to express my appreciation of the encouragement given me by Prof. G. E. Blackman, director of this Unit.

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Presence in Root Tips of a Thermolabile Factor causing the Conversion of Protochlorophyll to a Leuco-Compound

IN a previous paper[1], it was reported that protochlorophyll occurs in the tips of dark-grown roots. It was also shown that protochlorophyll disappears immediately after living root tips have been squashed. It also disappears from raw ether extracts during the evaporation of the ether. This implies that neither the pulp from squashed tips nor the watery residue dissolved in ether exhibits any red fluorescence. I have now succeeded in demonstrating that some thermolabile factor is responsible for this destruction of protochlorophyll.

To prepare an extract containing this factor, about 5 gm. of fresh root tips (apical part of root, about 0·5 cm. in length) from seedlings grown in 'Vermiculite' moistened with the nutrient solution were ground with sand in a mortar with 20 ml. of ether. The ether solution was decanted and used as a source of the factor. To activate this factor, however, it was necessary to remove the ether from the extract. Extracts from root tips of both *Zea mays* and *Helianthus annus* were tested.

The protochlorophyll was prepared as a raw extract from dark-grown wheat leaves according to Virgin[2], but in some series the leaves were first killed by immersion in water at 100° C. for 10 min. The following procedure was then used to determine the activity of the factor. 1 ml. of the extract from the root tips was put into an Erlenmeyer flask together with two drops of distilled water, and the ether was removed by evaporation *in vacuo*. The concentrated aqueous extract was kept for 10 min. at temperatures of 20° C. or at 100° C. (water-bath). 4 ml. of the protochlorophyll extract were then added and the ether removed. As a second evaporation increased the effect of the factor, 4 ml. of the ether were added to the aqueous residue after 2 min. at 20° C. and the ether was again removed. The extract was then diluted with 4 ml. of ether and its absorption in red light was determined spectrophotometrically by means of a Beckman spectrophotometer model *DU*. The fluorescence was estimated visually[1].

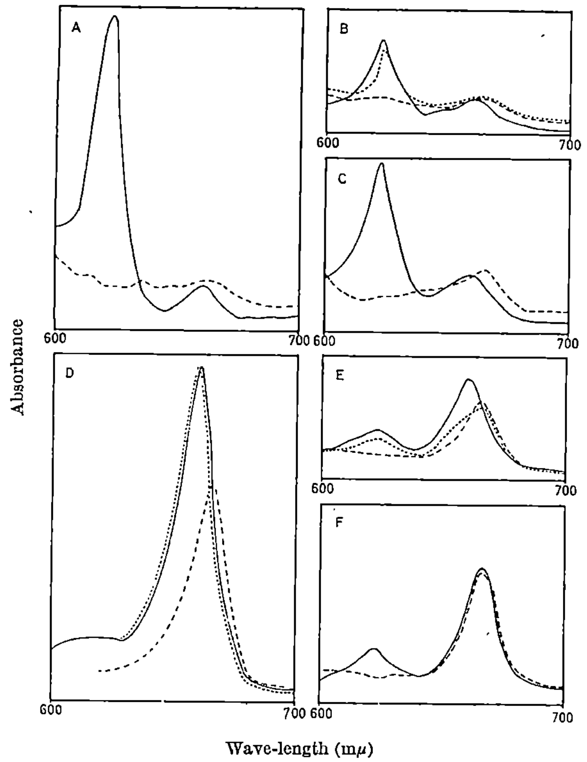

Fig. 1. Absorption of the different samples. ——, Initial absorption of the sample; ...., absorption after evaporation procedure without active factor; ----, absorption after test procedure with the active factor from root tips of *Zea* (*A*,*F*) and of *Helianthus* (*B*,*C*,*D*,*E*). *A*,*B*,*C*, samples containing protochlorophyll together with very small amounts of chlorophyll *a* (contamination due to imperfect green light during extraction). *D*,*E*, extracts containing chlorophyll *a* resulting from light transformation of protochlorophyll. Small amounts of non-transformed protochlorophyll present in *E* (crude extract) but not in *D* (purified extract). *F*, solution of purified pheophytin *a* in a mixture with raw extract of protochlorophyll

The results (Table 1, Fig. 1) indicate the following: the root-tip extract contains a factor which causes decomposition of protochlorophyll into a compound without red light absorption. When protochlorophyll was the only red fluorescing substance in the solution (without chlorophyll), the red fluorescence disappeared completely. This indicates that the product of decomposition is not protopheophytin, since if this were the case the solution ought to give a distinct red fluorescence[3]. The activity of the factor is destroyed by heating. The susceptibility to heating indicates that it may be associated with a protein (an enzyme ?).

Table 1. Absorption of the Test Solutions at the Point of Maximum of Red Absorption of Protochlorophyll (623 mμ). The red fluorescence determined visually according to the method earlier described (ref. 1) is given below the figures for the absorption. The values are the means from three determinations

Sample	Initially	Ether removed by evaporation and new ether added		
		Without root tip extract	Root tip extract added: at 20° C.	Root tip extract added: heated to 100° C. for 10 min.
Protochlorophyll from dark-grown wheat leaves. Root tip extract from *Zea mays*	0·013 strong	0·012 strong	0·005 none	0·013 strong
Protochlorophyll from dark-grown wheat leaves (also containing small amounts of chlorophyll *a*) (cf. Fig. 1*B*). Root tip extract from *Helianthus*	0·320 strong	0·032 strong	0·013 weak	0·033 strong
As above, but leaves were killed with hot water before extraction	0·012 strong	0·012 strong	0·005 none	0·013 strong

To determine whether this compound also acts on chlorophyll, etiolated leaves, before extraction, were illuminated for 10 min. with daylight in order to transform part of the protochlorophyll to chlorophyll *a*. It was found, however, that the evaporation of the ether from the raw extract resulted in a conversion of chlorophyll *a* into pheophytin *a*, independently of the presence of the factor in question (Fig. 1*B*). Chlorophyll purified on a saccharose column and dissolved in ether was unchanged during the evaporation of the ether. It was transformed to pheophytin, however, when a small amount of the extract from the root tips was added to the solution even when the extract had been previously heated (Fig. 1*D*). This means that the transformation of chlorophyll *a* into pheophytin *a* is not dependent on the factor in question but is rather due to some acidic impurities present in the extract.

To determine whether the factor exerts any effect on pheophytin *a*, pure pheophytin in ether solution alone and combined with a raw protochlorophyll extract were tested with the same procedure as used for protochlorophyll. One example is given in Fig. 1*F*. It can be seen that the factor has no influence on pheophytin.

The protochlorophyll in raw extract from etiolated wheat leaves mixed with an ether extract from root tips is fairly stable so long as the ether is not removed by evaporation. Since the evaporation of the ether from the extract resulted in an increase of the concentration of water, one may assume that the increased water content is responsible for the activation of the factor. The method of extraction of root tips with ether was employed only for its convenience in the test procedure. The factor probably dissolves in ether along with water and other substances, but to be active it requires a higher concentration of water than is present in the non-evaporated ether extract. The factor is not stable in the ether extract. Its activity disappears after two to three weeks at 0° C.

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An Observed 'Oxygen Effect' during Gamma-irradiation of Dried Bacterial Spores

On numerous occasions it has been shown that changes produced in aqueous biological systems by exposure to ionizing radiations of low specific ionization can be influenced by environmental conditions during irradiation. Since it is considered that environmental conditions affect the types and yields of free radicals formed on irradiation of water, the suggestion has been made that the observed biological changes are induced mainly by indirect action. Recent observations on irradiated non-aqueous synthetic macromolecular systems and on dry isolated cellular constituents have shown that changes produced by direct action can also be influenced by environmental

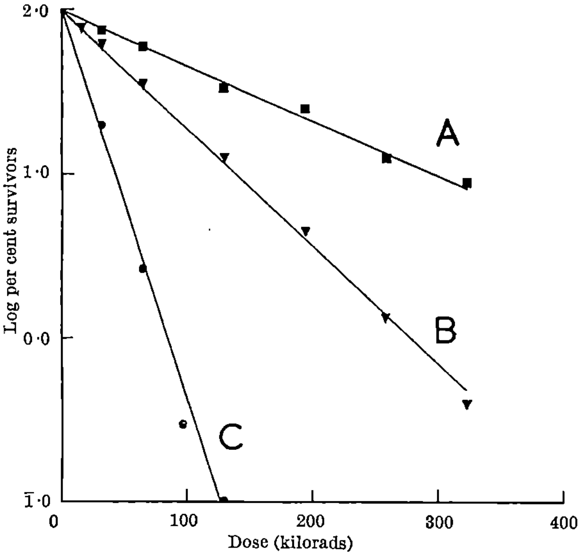

Fig. 1. γ-Irradiation of *B. subtilis* spores in kaolin powders sealed under reduced pressure and under air. *A*, secondary dried powder under reduced pressure; *B*, primary dried powder under air; *C*, secondary dried powder under air

conditions[1-3]. Alexander[4] has therefore postulated that direct action may cause changes in biological systems in cases where, in the past, it was thought that indirect action was responsible. However, alteration of the environmental conditions in circumstances where only direct action is known to be operative has not yet been shown to influence the lethal action of ionizing radiations on bacterial cells.

During a series of experiments involving γ-irradiation of spores of *Bacillus subtilis*, which had been dried in atmospheres of low aqueous vapour pressure, it has been observed that the presence of oxygen during irradiation influences their survival.

A powder, known to contain *B. subtilis* spores evenly distributed throughout it, was prepared by spray-drying a mixed aqueous suspension of kaolin and spores[5]. This is referred to as a primary dried powder. Glass tubes containing samples of known weights of this primary dried powder were attached to a glass manifold which in turn was connected to a two-stage rotary vacuum pump via a refrigerated moisture trap. Using this apparatus, the samples of primary dried kaolin powder were further dried for 6 hr. at a pressure of 0·001 mm. of mercury with liquid nitrogen as refrigerant. The powder dried in this way is referred to as a secondary dried powder. At the end of the secondary drying period, some of the samples of powder were sealed under reduced pressure (0·001 mm. of mercury) while others were sealed under air which had first passed through the moisture trap. Dose/log per cent survivor curves obtained from the γ-irradiation of spores in secondary dried kaolin powder sealed under reduced pressure and sealed under air, and the curve obtained from the irradiation of spores in primary dried powder sealed under air, are given in Fig. 1. The criterion of survival adopted was the ability of spores to produce colonies when sown into nutrient agar medium.

The low free-water content of bacterial spores[6,7] and the extreme drying conditions to which they are subjected during secondary drying probably ensure that killing of the spores on γ-irradiation occurs as a result of direct action. A comparison of curves *A* and *C* shows that the presence of air during irradiation greatly increases the kill of spores in secondary dried kaolin powder. This finding indicates that the observation of an 'oxygen effect' during irradiation of bacterial cells cannot be taken as evidence that indirect mechanisms are operative.

Comparison of curves *B* and *C* shows that spores in secondary dried kaolin powder, irradiated in the presence of air, are more sensitive to γ-radiation than spores in primary dried kaolin powder irradiated in the presence of air. This finding is of particular interest since the observed inverse relationship between moisture content and radiosensitivity is contrary to what would be expected from a consideration of the more usually reported protective effect resulting from dehydration of living cells. Further results from this series of experiments will be published elsewhere.

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Absence of Pectolytic Enzymes in a Pathogenic Strain of *Fusarium oxysporum* f. *lycopersici*

THE pectic enzymes produced by *Fusarium oxysporum* Schl. emend. Sny. and Han. f. *lycopersici* (Sacc.) Sny. and Han. have been considered to play an important part in the production of symptoms and of wilting in tomato plants infected with *Fusarium*[1]. It has been suggested that pectic enzymes are not responsible for the full range of symptoms[2,3] and that other metabolites may be involved. The pectic enzymes have also been considered important for the invasion of a wide range of plants by fungal parasites[2].

During the course of an investigation of the pectic enzymes of *Fusarium oxysporum* f. *lycopersici* an attempt was made to produce mutants which lacked pectic enzymes. The mutants were obtained by subjecting microconidia of strain *R*-5-6 (obtained from Prof. J. C. Walker, Wisconsin) to ultra-violet irradiation and a subsequent screening procedure. The usual method for isolating biochemically deficient mutants was reversed, the irradiated conidia being first plated out on a minimal medium (glucose-minerals) to eliminate any nutritionally deficient mutants. The colonies, arising from single microconidia, which developed on the minimal medium were screened over plates of pectin (B.D.H. 'Apple Pectin' Grade 240) agar and of pectate (sodium polypectate, California Fruit Growers Exchange) gel[4], and those which obviously differed in rate of growth from the wild type were selected for further study. The pectin and sodium polypectate used in the preparation of the screening media contained traces of glucose which facilitated at least limited growth of all survivors. A number of mutants were thus selected and their abilities to produce pectic enzymes and their pathogenicities were investigated under standard conditions.

The pectic enzyme activities of pectin–agar plate cultures and of liquid culture filtrates were estimated by modifications of the cup-plate assay method[5]. It was during these investigations that mutant strain 80, which produced no pectolytic enzyme, but which produced pectin methyl esterase, was found. This was afterwards confirmed using the Willstäter–Schudel hypoiodite method for polygalacturonase and the viscometric method for depolymerase.

Strain 80 was moderately pathogenic in the susceptible tomato variety Kondine Red either when seedlings were root inoculated or when cuttings were inoculated by the transpirational method[6]. The symptoms produced included petiole epinasty, some leaf yellowing and shrivelling, vascular browning, and vascular plugging. However, symptoms of more severe disease, such as severe wilting and collapse of the leaves and death of the plant, as might be seen in those plants inoculated with the wild type, *R*–5–6, were never apparent. The pathogenicity measurements were made with batches of twenty plants inoculated with each strain, under conditions which were optimal for disease development.

It is possible that the mutation (in strain 80) is one leading to a requirement for some specific substance for pectolytic enzyme synthesis and that this substance is available to some extent in the host tissues. If this is not the case, it can be concluded that pectolytic enzyme production is not necessary for the successful establishment of *F. oxysporum.* f. *lycopersici* in the host plant and that the pectolytic enzymes play no part in the production of symptoms in moderately diseased plants.

This work, the full details of which will be published elsewhere, has been carried out during the tenure of an Agricultural Research Council Research Studentship. I am indebted to Dr. N. F. Robertson under whose supervision the investigations were made.

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Initial Irradiation Reaction in Mice

EXPOSURE of the whole body to large doses of ionizing radiations produces an immediate effect in primates. In man the absorption of 500 r. of X-rays or γ-rays causes a sensation of lassitude, often accompanied by nausea and vomiting. In atomic-bomb casualties in Nagasaki and Hiroshima these symptoms developed[1,2] from one-half to several hours after exposure. The duration of the symptoms was short, ranging from a few hours to two days.

A similar reaction has recently been observed in monkeys. Hunter *et al.*[3] have reported that the behaviour of *M. mulatta* monkeys exposed to 450 r. of whole-body cobalt-60 γ-radiation changed shortly after irradiation. The activity of the animals was greatly diminished; they would sit quietly in a corner or lie down on the floor of the cage. This was accompanied in most animals by retching and vomiting.

In the course of various irradiation experiments we have observed a behavioural change in mice which is similar in some respects to the initial reaction occurring in man and monkeys. During the absorption of large doses of X-irradiation the mice quite suddenly became inactive. Most of them sprawled motionless on the floor of the cage with their hind limbs extended backwards. The mice in this inactive state seemed to respond normally to external stimuli such as noise and painful pressure on their tails. The duration of inactivity lasted from 5 to 30 min. after exposure.

We have termed the amount of total body irradiation which is required to bring about inactivation in mice, the 'inactivation dose'. In the present study we measured the inactivation dose in a number of mice to determine with what degree of constancy the phenomenon occurred; we also irradiated mice of different age groups to determine whether age had any effect on inactivation.

Forty-seven adult male white mice (Connaught Laboratory strain) were arranged in three age groups, namely, 2, 3½ and 4½ months. No animal received more than the amount of irradiation required to produce inactivation. All animals were observed for 30 days, and the deaths which occurred were recorded. A Ferranti (*RV*–220) therapy unit was used. The radiation factors were as follows: operating voltage, 200 kV.; tube current, 20 m.amp.; H.V.L., 1·55 mm. of copper. The animals were irradiated at a distance of 40 cm., which produced a dose rate in air of 48 r./min. In order to determine the time of inactivation with more accuracy than by visual observation, the following simple movement-recording device was used. The mouse was placed in a small wire cage which rested on a wooden platform under the X-ray beam. The platform was supported by four light coil springs, one in each corner. A piezo-electric crystal (recording cartridge) was attached to the side of the platform by its stylus and allowed to hang freely. In this manner the movements of the platform, made by the mouse, were transmitted to the crystal in which piezo-electric currents were produced. These electrical impulses were amplified and recorded on an ink-writing recorder (Varian Associates, Palo Alto, California). The X-ray unit

Table 1. THE RANGE AND AVERAGE VALUES OF THE INACTIVATION DOSE IN MICE OF DIFFERENT AGE GROUPS

	No. of animals	Average weight of animals (gm.)	Inactivation dose (r.)		*P*	No. of deaths	Mortality (per cent)
			Range	Av. S.E.			
2-month old mice	20	21·3	400–800	604 ± 26		11	55
3½-month old mice	20	27·6	375–725	512 ± 23	0·02	7	35
4½-month old mice	7	34·4	400–650	503 ± 32	0·05	0	0

was turned off when cessation of movement was noted and a permanent record was obtained.

The results are shown in Table 1. It will be noted that the dose required for inactivation decreases as the age of the animal increases. 2-month, 3½-month and 4½-month groups of mice showed average inactivation doses of 604 r., 512 r. and 503 r., respectively. The latter two values were both statistically different from the first value. 55 per cent of the youngest animals died when exposed to the dose required to produce inactivation, compared with 35 per cent deaths in the 3½-month group and no deaths in the 4½-month group.

There is considerable evidence[4] that age decreases the sensitivity of animals to irradiation. Older animals require more irradiation than younger animals to produce comparable degrees of leukopœnia, anæmia or lethality. It is, however, evident that the inactivation phenomenon does not follow the dosage relationship in this manner. If it did, we would expect to find that older animals required a greater amount of irradiation to produce inactivation than the younger animals. Our results show the reverse to be true, which suggests that the nature of inactivation is different from the other manifestations of irradiation injury.

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Corneo-Fundal Potential Variations during Light and Dark Adaptation

THE corneo-fundal potential (that is, the steady potential difference across the eye) was discovered in 1849 by Du Bois-Reymond[1]. Noell[2] has recently shown evidence that a part of the corneo-fundal potential is attributable to the membrane polarization of the pigment epithelium adjacent to the sensory cells of the retina. He found, while measuring the retinogram in rabbits, polarization changes lasting for more than 200 sec. following the onset of illumination. An analogous phenomenon, described in detail below, occurs in humans.

The surface-potential differences obtained from electrodes placed on the skin near the eyes (outer canthi) were shown by Mowrer, Ruch and Miller[3], in animals, to be related to the electrical polarization (cornea positive with respect to fundus) of the eye-bulb.

A method of surface-recording similar to that used by Miles[4] for studies of individual differences in humans was modified by Kris[5], giving the results described here.

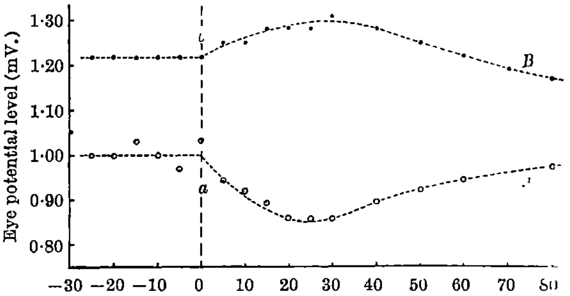

Fig. 1. Curves of variation of eye potential-level changes at onset of (○ – – ○) light adaptation, and (● – – ●) dark adaptation. *a*, Light on; *b*, light off. Measurements taken from left eye *D*–*C* horizontal record of subject *SS*, sections 1_1 and 1_{14}

When the eye has been adapted either to light or dark, a step-change in illumination produces an initial transient effect lasting between 60 and 80 sec., as shown in Fig. 1.

For light-adaptation, the initial transient dip (curve *A*) is followed by a fluctuation resembling a damped oscillation of 30 min. period, lasting approximately one hour (Fig. 2). The peak and trough times observed in 18 complete light-adaptations by six subjects fell within the following ranges: 1st peak at 10th min. ± 2 min.; 1st trough at 25th min. ± 4 min.; 2nd peak at 36th min. ± 4 min. These variations include the diurnal variations of three subjects who were adapted repeatedly over a 30 hr. test-period[6]. One subject, who did not show initial transients, reported red-green colour-blindness. While the pattern of fluctuation was the same for light-adaptations to illumination intensities of 7 and 140 millilamberts, the amplitude of fluctuation was higher with the higher level of illumination (Fig. 2, *a* and *c*).

For dark-adaptation following complete light-adaptation, the initial transient rise (Fig. 1, curve *B*) is followed by a fall in potential-level over the first 8–10 min., and then by a gradual rise (taking approximately 20 min.) to a steady-state level which is regularly somewhat lower than that of the light-adapted steady-state level. See Fig. 2, section *b*, which shows the first 20 min. of a dark-adaptation curve.

The presence of a damped oscillation suggests a homœostatic mechanism.

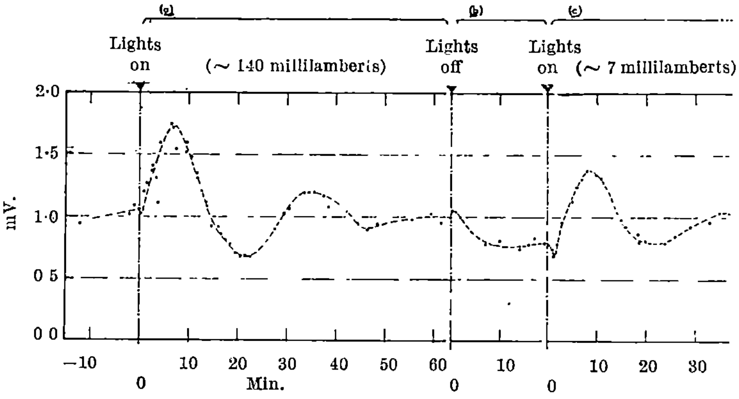

Fig. 2. Changes in eye potential-level during adaptation successively to (*a*) strong illumination; (*b*) darkness; (*c*) moderate illumination. Subject: *RS*. Ordinates: change in potential across electrode-pair lateral and mesial to left eye, produced by standard 60° horizontal fixation shifts

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A Water-soluble, Diffusible Pigment produced by a Strain of *Serratia marcescens* (*Chromobacterium prodigiosum*)

Members of the bacterial species, *Serratia marcescens*, are characterized by the production of red or pink pigments. These pigments are described as being insoluble, or sparingly soluble in water, and to be associated with the bacterial cell[1,2]. Heavily pigmented strains show some diffusion of pigment into agar media, but the organisms still retain most of the colour[2,3]. We wish to report a red-to-pink pigment produced by a strain of *S. marcescens* which not only is readily soluble in water, but which also diffuses from the organisms into the medium and leaves the cells colourless.

S. marcescens strain 125 was received from Dr. L. S. McClung of the Department of Bacteriology, Indiana University, Bloomington. The strain had been identified as *S. marcescens* by Hamilton[4]. Tests carried out in our laboratory demonstrated that the organism was a small, motile, cocco-bacillary, Gram-negative rod. It fermented glucose, mannitol, and sucrose without the production of gas. Lactose and maltose were not fermented. The citrate and nitrate tests were positive, but those for hydrogen sulphide production, indole, and urease were negative. Gelatin was liquefied. With the exception of the failure to ferment maltose, these characteristics are those of *S. marcescens* organisms as presented in authoritative sources[1,2,4,5]. Electron microscopy showed the presence of peritrichous flagella. The organism did not produce pigment when cultivated at 37° C.

For pigment production, strain 125 was grown in 5-l. Povitsky toxin bottles containing 1 l. of casein hydrolysate–yeast extract–agar medium[6]. The cultures were grown for 5 days at 27° C. The colourless cells were scraped from the agar surface and discarded. The agar was homogenized in a high-speed blendor, and then washed continuously on a Buchner funnel with distilled water until the maximum amount of pigment had been extracted. The pigment was adsorbed from the filtrate on to activated charcoal ('Darco *G*–60', Atlas Power Co.), and after adsorption the charcoal was washed several times with distilled water. The pigment was eluted with glacial acetic acid, dried *in vacuo*, and the residue dissolved in a small amount of distilled water. Since the pigment is insoluble in petroleum ether this solvent was used for washing the water solution several times to remove contaminating substances. Final purification of the pigment was effected by continuous paper electrophoresis in 5 per cent acetic acid on a 'Spinco' Model *CP* unit. The pigment moved as a single band, and all of it was collected in only two tubes. Acetic acid was removed from the eluate by drying *in vacuo*, and washing the dried material several times with petroleum ether. The pigment was then dissolved in a small amount of distilled water, lyophilized, and stored as the dry substance.

The purified pigment was red to pink in colour, and was insoluble in acetone, chloroform, ether and petroleum ether, but was soluble in ethanol, methanol, and water. In solvent systems composed of lutidine and water (5 : 3), and *iso*propanol, concentrated hydrochloric acid and water (65 : 16·6 : 18·4) the pigment moved as a single band. The bands showed no fluorescence under short or long wave-length ultra-violet light. Paper electrophoresis demonstrated that the pigment moved as a single substance in barbiturate buffer, *p*H 8·6, as well as in acetic acid. The isoelectric point in acetate buffer was *p*H 3·5. After combustion of material eluted from chromatograms, there still remained considerable ash. Therefore chemical analysis of the pigment must await more complete purification. Efforts to crystallize the pigment have thus far failed. The acid, base and neutral spectra of the pigment are presented in Fig. 1. The spectral maxima are at 550 and 280 mμ, and the minimum is at 425 mμ. These values do not vary with changes in *p*H, although the shape of the curves is somewhat modified.

To our knowledge this is the first time a water-soluble, diffusible pigment of *S. marcescens* has been

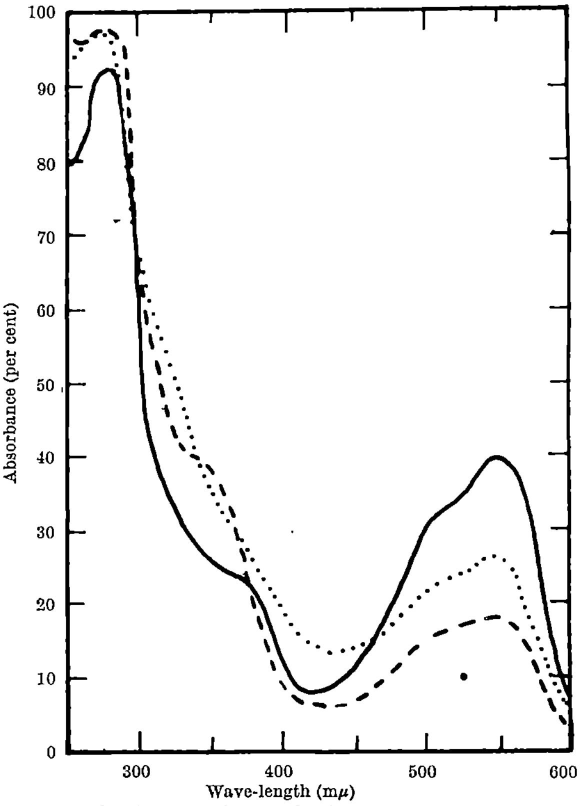

Fig. 1. Spectra of water-soluble, diffusible pigment from *S. marcescens*. ––– in acid, *p*H 4 ; . . . in alkali, *p*H 9 ; —— in neutral solution. All spectral determinations were carried out in water solutions

reported. The biochemical tests establish the fact that strain 125 is *S. marcescens*, and the presence of peritrichous flagella, as well as the fermentation reactions, indicate that the organism cannot belong to the pseudomonad group. It has been pointed out that *Serratia* organisms can vary widely in their ability to produce pigment, and in the colour of the pigment[1,2]. Thus it should not be surprising to find that certain strains produce a diffusible, rather than a cellular, pigment.

It is of interest to compare certain properties of extracted cellular pigment with those of diffusible pigment. In contrast to the latter substance, cellular pigment is insoluble in water, but readily soluble in acetone, chloroform, ether and petroleum ether[6]. It cannot be moved by paper electrophoresis. Both pigments are red in colour, but the diffusible pigment is of a lighter shade. The spectrum of the cellular pigment shows marked shifts with variation in *p*H, and the maximum peaks in acid solution are at 540, 375 and 275 $m\mu$, and the minima, at 420 and 330 $m\mu$ [6]. As can be seen in Fig. 1, the spectrum of diffusible pigment shows little variation with changes in *p*H, and although the acid curve has maxima and minima similar to those of cellular pigment, the two spectra are not identical. Cellular pigment also can be separated into several fractions[6], whereas diffusible pigment appears to be a single substance. Thus with respect to the above characteristics, there are marked differences between cellular and diffusible pigment. Whether there are any relationships in chemical structure between the two pigments must await further investigations.

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Serum Protein Variations in Horses

It is now clear that intraspecific serum protein variation is widespread in mammals at least, and that the technique of starch-gel electrophoresis developed by Smithies[1] is a powerful tool for revealing these differences. Complex protein patterns have been obtained with sera from horses, due to concomitant variation in several protein systems.

Sera from 79 thoroughbred and other ('knacker') horses of unspecified breed were examined, using *p*H 7·6 phosphate buffer and electrolyte as described previously[2]. Four variable systems were found, namely, the β-globulins, pre-albumins and two apparently unrelated α-globulin systems. Electropherograms of three sera illustrating these variations are shown in Fig. 1. A diagram of a two-dimensional agar/starch-gel electropherogram[2] of another serum is shown in Fig. 2.

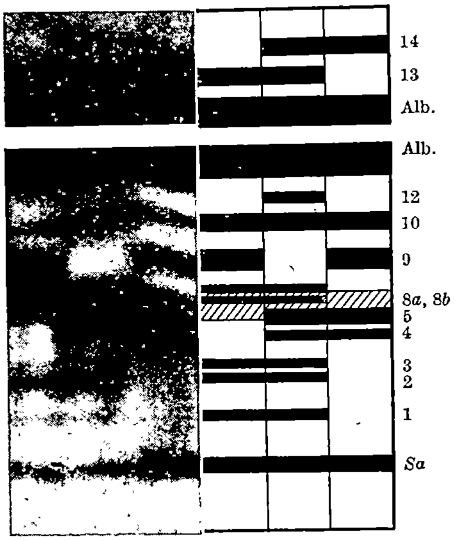

Fig. 1. Starch gel electrophoresis protein patterns from three representative horse sera. Only the anodic side of the gel is illustrated. The main part of the gel was from a 5-hr. run at 200 V.; the pre-albumin portion was from a separate 3-hr. run at the same voltage. Alb., albumin; *Sa*, slow-alpha globulins; 1–6, β-globulins; 8*a*, 8*b* and 9, first variable α-globulins; 12, second variable α-globulin; 13 and 14, pre-albumins. Zone 7 (cross-hatched) is usually rather diffuse and occurs in the region of zones 5, 6 and 8

Three β-globulin types were observed. It is possible that these represent the homozygotes and heterozygote of two β-globulin alleles, one producing zones 1, 2 and 3 and the other zones 4, 5 and 6. This would be comparable with previously described β-globulin systems in other species[3].

Three types have been found in the first of the variable α-globulin systems depending on the presence of either or both zones 8 and 9. In some gels zone 8 is resolved into two zones, 8*a* and 8*b*, but neither of these has so far been found alone. The α-globulin zone 7 is apparently always present but is not sharply defined. In one-dimensional runs it appears in the

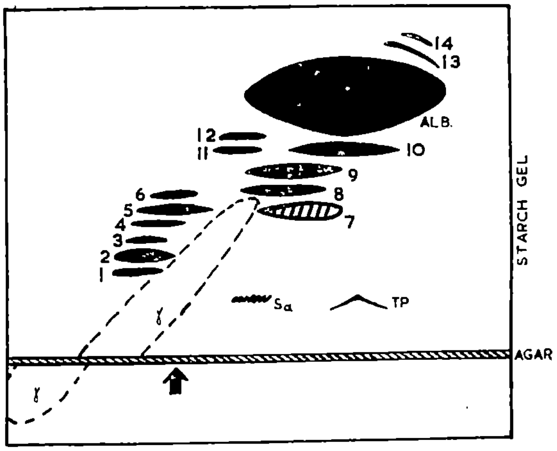

Fig. 2. Diagram of a two-dimensional electropherogram of a selected horse serum. The arrow indicates the position of insertion of the original sample in the agar. γ, γ-globulins; *TP*, thread protein. See also key to Fig. 1

region of zones 5, 6 and 8 as a diffuse band. Experiments with added hæmoglobin suggest that this may be the hæmoglobin-binding protein (haptoglobin).

The second variable α-globulin system has shown two types depending on the presence or absence of zone 12. The distinction between these types is not always easy in one-dimensional runs, but is made more readily in two-dimensional separations.

At least three pre-albumin types have been observed in the sera examined, depending on the presence of either or both zones 13 and 14. However, a third pre-albumin zone, intermediate in mobility to the other two, has been seen in two sera, but only in the absence of zone 14.

It will be necessary to examine an appropriate number of related individuals to determine if these variations are inherited, that is, constitute further examples of serum protein polymorphism.

I thank Mr. A. Thomson, of the Wellcome Research Laboratories, and the staff of the Equine Research Station of the Animal Health Trust for providing horse sera, and K. F. Mitchell for technical assistance.

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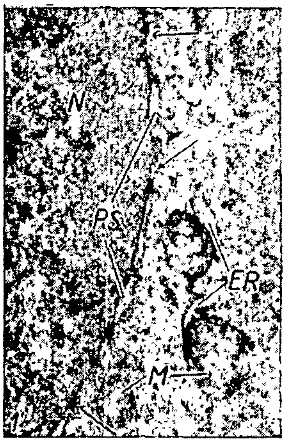
Fine Structure of the Nuclear Envelope of Carcinoma Cells

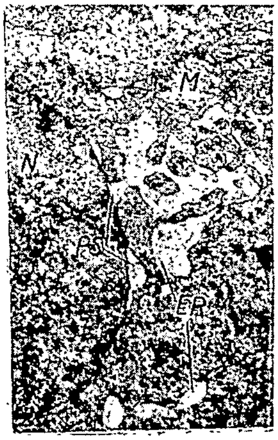
Palade[1] was the first to observe with the electron microscope that the plasma membrane forms invaginations which occasionally plunge deeply into the cell body. He has shown that the lumen of the infoldings of the cell membrane communicates with the interior of the endoplasmic reticulum. Watson[2] showed that in certain cells the outer nuclear membrane is continuous with the membrane system of Palade's reticulum. Therefore, his 'perinuclear space' is part and parcel of the cavities of the endoplasmic reticulum. By demonstrating that the inner and outer nuclear membranes fuse at the edges of the nuclear pore, Watson[2] suggested that the nuclear envelope is simply a specialized form of endoplasmic reticulum.

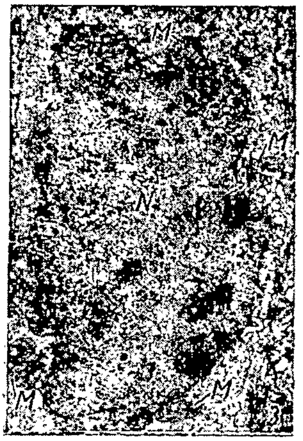
Those considerations about the continuity of the lumen of the endoplasmic reticulum and the perinuclear cisterna are based on electron micrographs of acinar cells of the pancreas, of parenchymatous liver cells and phagocytes and of Rous tumour cells[3]. It was suggested that a relation exists between the magnitude of such structures and the type of activity of the cell under consideration.

During morphological work on cells of chemically induced carcinoma of the cervix uteri of mice, electron micrographs were obtained in which structural details of the nuclear envelope were found to be strikingly similar to those mentioned above. The existence of a double nuclear membrane is shown in Figs. 1 and 3. In some of the carcinoma cells (Fig. 2) the outer nuclear membrane appears to be lifted up and continuous with the endoplasmic reticulum. Moreover, the portion of the endoplasmic reticulum with a rough surface is highly developed and the cytoplasmic matrix of this cancer cell is reduced to narrow strands lying between the swollen cavities of the reticular system (Fig. 2).

Many of the malignant cells show several nuclear indentations, a fact sufficiently known from light microscopy. The electron microscope clearly shows that both the outer and inner nuclear membranes participate to the formation of true nuclear infoldings







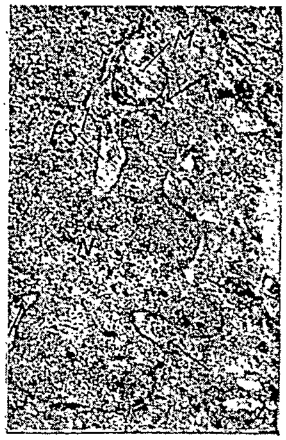


Fig. 1. Electron micrograph of a portion of a nucleus (*N*) and adjoining cytoplasm of a cancer cell. The two layers of the nuclear envelope and the perinuclear space between them (*PS*) are apparent. Nuclear pores are indicated by the arrows. Near the nuclear envelope the cytoplasm contains several mitochondria (*M*) and profiles of rough-surfaced membranes of the endoplasmic reticulum (*ER*). (× 38,000)

Fig. 2. Electron micrograph of another cancer cell from the same tissue as Fig. 1. The granular nucleus (*N*) occupies the left part of the picture. The outer nuclear membrane is reflected into the cytoplasm in such a way that the perinuclear space (*PS*) is clearly continuous with the interior of the labyrinth of the endoplasmic reticulum (*ER*). At the upper left corner another nucleus also bounded by a double nuclear membrane. (× 29,500)

Fig. 3. Electron micrograph of a nucleus (*N*) of another cancer cell from the same tissue as Figs. 1 and 2. Between the double nuclear membrane the perinuclear cisterna is apparent (arrows). A great number of mitochondria (*M*) are closely associated with the depressions of the nuclear envelope. (× 20,000)

Fig. 4. Electron micrograph of a part of another cancer cell of the same tissue as Figs. 1, 2 and 3. The granular nucleus (*N*) shows several deep indentations (arrows). At *PS* the perinuclear space is seen between the inner and the outer nuclear membrane. A mitochondrion (*M*) lies as if waiting for the contents of the indentation. (× 32,000)

(Fig. 4). While the perinuclear space contained within the infoldings may be small, at other sites it is very large (Fig. 4). In addition, it is in direct contact with an important part of the nuclear surface and builds close connexions with deep-seated nuclear areas.

Palade[4] and others suggest that the mechanism of plasma membrane flow may play an important part in securing active transport of substances in both directions through the cytoplasm. Palade[4] has also shown that such cytoplasmic membranes are topographically often closely associated with mitochondria. Fig. 3 shows the nucleus of a cancer cell bounded by an undulating nuclear envelope: within the depressions mitochondria can be seen, closely associated with the nuclear membranes. Fig. 4 illustrates several deep indentations; at the opening of one of them lies a very large mitochondrion.

These nuclear membrane invaginations in cells with active protein synthesis suggest the existence of a mechanism of nuclear membrane flow compensating for increased metabolic exchanges between nucleus and cytoplasm.

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Phosphatidyl Serine and Blood Coagulation

An important aspect of blood coagulation research is the chemical definition of the reacting substances and a question of current interest is the composition of platelet thromboplastic factor.

Previous reports[1,2] have described the clotting activity of brain lipid fractions containing phosphatidyl serine and phosphatidyl ethanolamine; the former inhibited thromboplastin formation while the latter showed acceleratory activity like that of platelet suspensions. Coagulation inhibitory activity has been ascribed to phosphatidyl serine extracted from brain[3,4]. However, Troup and Reed[5] have reported that both phosphatidyl serine and phosphatidyl ethanolamine isolated from platelets potentiated thromboplastin formation, the former compound being the more active. Biggs and Bidwell[6] were unable to associate platelet-like activity of brain phospholipids with any one substance; all were found to be acceleratory. Rapport[7] stated that a brain phosphatidyl serine preparation accelerated coagulation and that this was enhanced by lecithin. Rouser, White and Schloredt[8] found that acceleratory activity was confined to the phosphatidyl ethanolamine component of the platelet lipids.

We have now found that phosphatidyl serine can act as an accelerator (like platelets) or as an inhibitor (as previously reported) of thromboplastin formation, depending on the experimental conditions. Thromboplastin formation was inhibited when the phosphatidyl serine in aqueous solution was placed in the reaction mixture. However, when the phosphatidyl serine was first suspended in aluminium hydroxide adsorbed ethylenediamine tetraacetic acid plasma and then added to the reaction mixture, thromboplastin formation was enhanced. This potentiating effect was not found when citrated or oxalated plasma was employed.

Table 1. Thromboplastin Formation as affected by variously prepared Materials with and without Phosphatidyl Serine
The figures in the body of the table express clotting time of the substrate in seconds

	Test material	Incubation time (min.) 2	4	6	8	10
	Buffered saline	60	43	30	26	25
	Platelets	26	10	9	9	10
P.S. 2 mgm./ml. in	EDTA plasma	75	14·5	10·5	10	10
	Citrated plasma	96	66	55	54	50
	Oxalated plasma	100	75	57	52	46
	0·005*M* EDTA	112	103	89	89	85
	Buffered saline	116	105	100	80	77
	EDTA plasma	90	56	43	34	33
	Citrated plasma	82	44	27	23	26
	Oxalated plasma	81	45	37	35	30
	0·005*M* EDTA	92	64	48	42	36

P.S., phosphatidyl serine; EDTA, ethylenediamine tetraacetic acid.

The phosphatidyl serine was prepared from pork brain and on paper chromatography (method of Marinetti and Stotz[9]) consisted of phosphatidyl serine with traces of the lyso compound. Thromboplastin formation was measured by the Biggs–Douglas test[10]. Plasma poor in platelets was separated from normal human blood collected into 1/10 volume of each of the following anticoagulants: 0·027 *M* ethylenediamine tetraacetic acid (the disodium salt of ethylenediamine tetraacetic acid), 0·1 *M* sodium oxalate, and 0·13 *M* trisodium citrate. These plasma were then treated with aluminium hydroxide to remove prothrombin and related factors. The one-stage prothrombin time (with brain thromboplastin) of the adsorbed ethylenediamine tetraacetic acid plasma was greater than 10 min. The phosphatidyl serine was suspended in each of the three plasmas, in buffered saline, and in 0·005 *M* ethylenediamine tetraacetic acid, to a concentration of 2 mgm./ml. Each suspension (0·2 ml.) was substituted for platelets in the Biggs–Douglas test.

The results are shown in Table 1. The buffered saline suspension of phosphatidyl serine was clearly inhibitory. (As previously reported[2], inhibition was also found in the presence of platelets.) However, the phosphatidyl serine in ethylenediamine tetraacetic acid plasma simulated the acceleratory activity of platelets; this activity was maximal at 0·5 mgm./ml. On the other hand, the phosphatidyl serine in oxalated or citrated plasma was somewhat inhibitory or inert. To investigate the activating effect of ethylenediamine tetraacetic acid plasma, the possibility that this acid alone produced the change was examined. The phosphatidyl serine in 0·005 *M* ethylenediamine tetraacetic acid (the calculated plasma concentration) showed only inhibitory activity.

The possibility of some interaction with other lipids[7] in the presence of ethylenediamine tetraacetic acid was also investigated. The total lipids from platelet-poor plasma was mixed in varying proportions with the phosphatidyl serine in 0·005 *M* ethylenediamine tetraacetic acid. Under these conditions only inhibitory activity was found. This result does not exclude the possibility of lipid interactions under other conditions.

Our phosphatidyl serine preparation (in buffered saline) at appropriate concentrations also accelerated the coagulation of citrated plasma by Russell viper venom ('Stypven' of Burroughs Wellcome) although at higher concentrations venom activity was depressed.

We have detected both phosphatidyl serine and phosphatidyl ethanolamine (as well as other lipids) in normal human platelets by paper chromatography. This finding is in agreement with that of Troup and Reed.

These observations may help to resolve some of the apparently conflicting reports referred to earlier. They also show that the activity of a substance (at constant concentration) may be reversed, thus emphasizing the importance of the particular assay conditions. This work will be reported in greater detail elsewhere.

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Standard Atmospheres in Respiratory Physiology

Pugh[1], observing on Everest pressures "higher than those calculated according to the standard altimeter calibration" with differences physiologically important above 18,000 ft., rejects the International Commission for Air Navigation (ICAN) 'atmosphere', preferring the temporarily more convenient formula of Zuntz *et al.*[2]. This formula promises to achieve a mystical superiority in high-altitude physiology[3].

The International Commission for Air Navigation 'atmosphere', an approximate world mean atmosphere convenient for altimeter calibrations, is, like any other calculated from simplified formulæ, inaccurate when surface pressure or vertical temperature distribution differs from 'standard'. To correct an altimeter reading accurately, whatever model atmosphere its basis, the complete vertical distribution of virtual temperature below the observer must be known. Assumed 'mean temperatures' will only by chance be satisfactory, particularly if temperature inversions exist below.

Haldane and Priestley[4] and Miss Fitzgerald[5] did not "indicate that the (Zuntz) formula is a better guide to barometric pressure in mountains than the accepted formula for calibrating altimeters" (Pugh, ref. 1). They were clear that the success of any simple formula which does less than fully integrate the weight of air below the observer depends on locality and season. It is unfortunate, therefore, to imply that the Zuntz formula somehow fits "conditions in mountains rather than free air", taking no account of time and place. On a similar mountain in high latitudes, actual pressures would have been lower than those of the International Commission for Air Navigation atmosphere.

Fig. 1 shows the mean departures from the International Commission's 'atmosphere' of the actual seasonal mean pressures measured at three representative latitudes along meridian 80° W. (from data published in a different form[6]). These curves are idealized. Secular variation, continental, oceanic and local topographical climatic influences scatter individual observations considerably, but the pattern is clear: at low latitudes, mean pressures exceed those of the International Commission 'atmosphere', increasing with height to about 10 per cent excess at 40,000 ft., whereas at high latitudes in winter the situation is reversed.

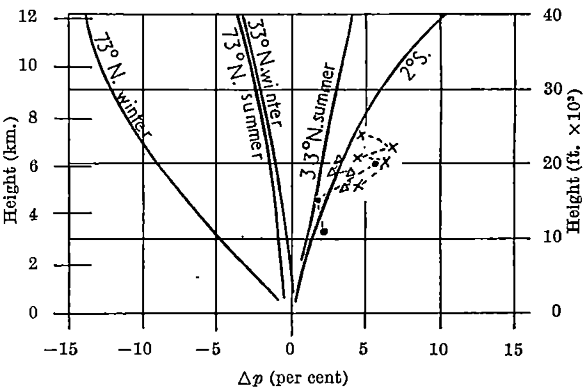

Fig. 1. Seasonal mean pressure deviations from the International Commission for Air Navigation pressures as a function of height, latitude and season. Δp, Excess pressure at each height as a percentage of the International Commission pressure; ●, Pugh (1952) Cho Oyu; △, Williams (1956) Karakoram; ×, Pugh (1953) Everest

Hess's values are fairly representative; the range in height of the mean January and July 300 mb. pressure-levels computed by Bannon[7] confirm these results, as do those of Wexler[8].

Given the local air temperature, differences between the International Commission's heights and those in the real atmosphere at which a given pressure is reached may be computed. Thus, in low latitudes, the International Commission's pressure for 40,000 ft. is usually attained at 42,000 ft. and at high latitudes in winter it is already reached at 37,000 ft.

Since even 'standard' atmospheres display secular drift[8], it may be preferable in high-altitude physiology to think first in terms of pressure, preferably directly measured, relegating altitude *per se* into its evident secondary role.

A final comment may avoid confusion. Pugh, discussing pulmonary ventilation, states that "normal variability of resting ventilation . . . is such that one would not expect to see any close relationship with relatively small changes in altitude, particularly at higher altitudes where change of barometric pressure with height is considerably less than at sea level". This poor correlation is probably entirely due to biological variability. At these altitudes, the fractional pressure change with height, which is the relevant factor, is in fact more rapid than lower down.

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The Enigmatical Trematode "*Dictyocotyle coeliaca*"

Dictyocotyle coeliaca Nybelin, 1941, the only monogenetic trematode ever to be found in the cœlom of a vertebrate, was described from two specimens, one from *Raia lintea* near Skagen and the other from *R. radiata* at Trondheim. Ten years ago one of us described two other specimens from *R. clavata* and expressed the hope that a look-out would be kept for the trematode in zoological laboratories[1]. This appeal brought nine specimens from J. E. N. Sloan, formerly of the Zoology Department, University of Edinburgh, and it seems to have led to the publication of two original papers. In neither paper was the total number of parasites specified, but 16 out of 55 *Raia naevus* and 31 out of 73 *R. radiata* taken on Scottish fishing grounds[2] and 35 out of 135 *R. naevus* landed at Plymouth[3] were infected. Mean numbers of parasites per fish were 7 and 4 respectively, and in each instance rays of other species did not yield any parasites. This trematode closely resembles the common cloacal parasite *Calicotyle kroyeri*, differing chiefly in the nature of the posterior adhesive organ (opisthaptor), which is a delicate hookless disk showing faint markings or irregular shapes and sizes. These simulate but are not suctorial compartments, or loculi, such as are found in *Calicotyle* and other Monocotylidae, and mainly for this reason the taxonomic status of *Dictyocotyle* remains undetermined. Llewellyn and Green[3] believe it "distinctly possible" that the host landed at Brixham "had been mis-identified". When at the time confirmation was sought, Dr. E. B. Francis was emphatic, stating, "the species of *Raia* (as mentioned in my previous letter !) was '*clavata*', source Brixham" (letter dated March 26, 1947).

With the finding of new specimens, the senior author recognized the possible validity of the species, though not of the genus[1]. This brought from Dr. H. A. Baylis the comment (*in litt.*, May 3, 1948) : "I cannot help feeling sorry that you have now given your blessing to what I am quite sure is a fictitious species. In your book 'The Trematoda' you said, 'in any case it seems safe to assume . . . that *Dictyocotyle coeliaca* is an abnormal form of a species of *Calicotyle*, probably *C. kroyeri*'. With that view I entirely agree, and still agree, having seen the specimens found at Cambridge, to which you refer". However, the authors of the two papers mentioned[2,3] have accepted both genus and species as valid. Such a taxonomic tangle would be a small matter were it not for the extraordinary nature of the trematode concerned. This and the appeal for new specimens has induced the junior author to examine over a period of five years *Raia radiata* obtained from Plymouth, with the result that 38 additional specimens have been found. Of these, 27 were taken from the anterior part of the liver, 3 from the vicinity of the kidneys, and 7 from the body cavity quite near the openings of the abdominal canals. The canals themselves were dissected consistently and one trematode was actually found inside one of them. Evidently, it had been preserved in the act of passing from the cloaca into the body cavity, and the longitudinally folded condition of the body indicated that passage had not been easy. Moreover, this specimen had lost the opisthaptor, the stalk and adjacent tissue remaining as a kind of button or boss. The missing haptor was not found in this instance, but six isolated opisthaptors were recovered from the cloaca in other instances, along with a total of 317 entire specimens of *Calicotyle kroyeri*. These adhesive organs had evidently been torn from the body of the trematode, each of them having a central perforation which matches the boss of the mutilated specimen (Fig. 1*B*). The boss thus seems to correspond to the stalk plus the torn-out central portion of the opisthaptor (cf. Fig. 1*A*). It was observed also that such mutilation can be induced artificially, presumably because of a line of weakness between the central and peripheral portions of the opisthaptor.

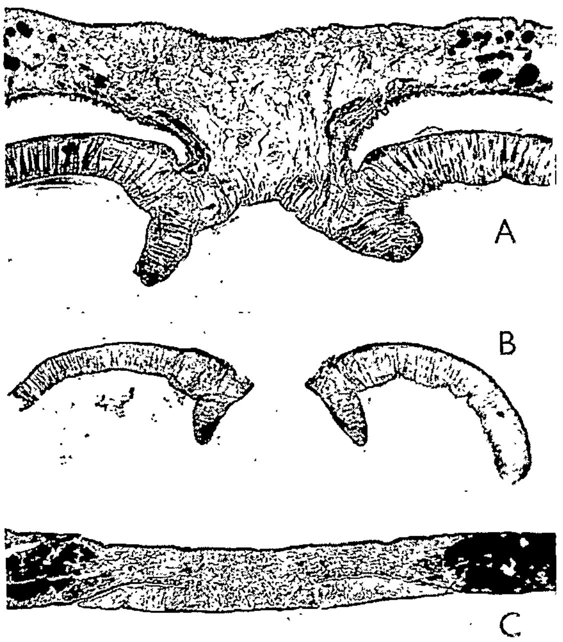

Fig. 1. Transverse sections, dorsal side above, ventral side below. (*A*) *Calicotyle*, showing part of the body (above) and two loculi of the haptorial disk plus the central boss (below). (*B*) discarded opisthaptor of *Calicotyle*, two of the peripheral loculi indicated, boss missing. (*C*) '*Dictyocotyle*', showing the delicate disk without loculi (below) which, it is suggested, is regenerated from the boss of a mutilated specimen

Because of these findings we give it as our considered opinion that *Dictyocotyle coeliaca* is simply a cœlomic form of *Calicotyle* which has entered the body cavity via one of the abdominal pores, which has lost the normal opisthaptor, and which has afterwards modified the central boss by regeneration in such a manner as to produce a delicate hookless disk without true loculi, that is, a pseudohaptor. This conclusion is supported by histological findings regarding the structure of the opisthaptor in the cœlomic form, which shows none of the characters of the normal adhesive organ of the Monocotylidae and which, like the boss of the mutilated form, shows a paucity of muscular tissue (Fig. 1*C*).

That *Calicotyle* may penetrate the slit-like abdominal pores of certain rays is certain, and in one instance on record the trematode did not lose its opisthaptor. This specimen was collected on April 7, 1868, by L. Esmark in the body cavity of *R. radiata.* Apropos of this record Brinkmann has stated[4]; "this location must be assumed to be accidental, or more probably erroneous. The location might suggest the parasite to be *Dictyocotyle coeliaca* Nybelin, but the examination of this specimen, however, shows that it is undoubtedly *Calicotyle kroyeri*". There is no reason, we believe, to doubt the record of Esmark, who discovered at least three trematodes new to the Norwegian fauna. If *Calicotyle* penetrates the cœlom without mutilation identification is easy; what is not easy is to recognize the after-effects of mutilation, or of existence in a wrong location. Regeneration seems to modify the boss of the mutilated trematode in various ways, leading to the inconstant patterns of markings on the disk ultimately formed (cf. the figures in refs. 1; 2, Fig. 1 (5); and 3, Pl. 1, Fig. 1).

We believe that Baylis was not very wide of the mark when he wrote regarding the damaged haptor (*loc. cit.*): "When torn away from the cloaca, the worm sometimes leaves behind the ventral half of its opisthaptor, still no doubt firmly attached. The dorsal half of this organ shows a reticular pattern due to the presence of a complicated system of muscle fibres which radiate like rosettes from a number of centres, and it is this reticulation which produces the appearance of a large number of loculi, as I have demonstrated by re-staining the Cambridge specimens". (These specimens, we might add, are the ones which Brinkmann identified as *Dictyocotyle coeliaca*, not in 1952 as Llewellyn and Green indicated, but in 1943, that is about five years before Baylis re-examined them.) We doubt the loss of the ventral half of the haptor, however, and suggest that it is the regenerating boss of the mutilated haptor which develops a reticular pattern, for such a reason as Baylis gave. The problem requires further investigation and is being investigated. We would suggest to others interested in the problem that what is required is information on the incidence of both cloacal *and* cœlomic forms where these co-exist, and particularly of the factors which influence the transition. It would be useful also to study the reasons for the failure of the cloacal forms to penetrate into the body cavity of certain species of *Raia* which harbour species of *Calicotyle*.

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Tubule Formation in Rat Brains by Monkey Kidney Cells previously grown *in vitro*

THE brain has been employed in this laboratory as a site for the transplantation of malignant cells from tissue culture to rat[1], and such transplantations are proving useful for both oncological and virological investigations. On the assumption that this procedure may also provide a new approach for the study of the nature and mechanism of alterations occurring in cells grown *in vitro* it was decided to apply the procedure to normal monkey cells grown in tissue culture.

Primary cultures of *M. rhesus* kidney were harvested from bottles by means of trypsin (0·06 per cent), centrifuged at 100*g* and resuspended in an amount of diluting material so as to yield approximately 15 million cells per ml. The diluting materials were either the growth medium used for *in vitro* cultivation of cells (solution 199 plus 5 per cent calf serum) or the supernatant fluid from a crude extract of tumour tissue (usually rat-passaged tumour derived from Hep 3 carcinoma). The suspended cells were injected intracerebrally (0·1 ml.) into young Wistar rats which had previously received X-radiation (320 r.) and cortisone (two injections of 3–5 mgm. each). At several intervals the animals were killed and the brain removed for histological examination. The results showed that not only did monkey renal cells survive and perhaps multiply in the rat brain, but also that these cells actually assembled in groups giving rise to tubular structure. One could find epithelial-like cells in nests, aggregates and tubular arrangements in various parts of the brain. The tubular structures were especially prominent, in several instances, in the meninges of the sulci. This is shown in Fig. 1. At first it was thought that tubule formation was more pronounced following the exposure of the cells to tumour extract. Subsequent experiments did not reveal such an 'inducing' capacity in the extracts.

Thus, cells derived from adult kidneys, dissociated from their original organization, cultivated in an undifferentiated monolayer *in vitro* appeared com-

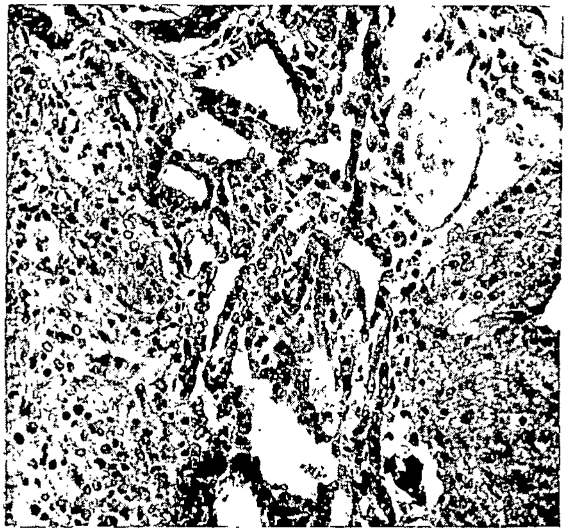

Fig. 1. Brain seven days following injection of trypsinized monkey kidney cells in tissue culture. There are numerous epithelial tubules in the meninges of a cerebral sulcus. Hæmatoxylin and eosin stain. (× 160)

petent to reconstruct the structure of their origin. Is this ability resident in adult kidney epithelium ? According to Oliver *et al.*[2], nephron reconstitution as contrasted with epithelial cell regeneration in damaged kidney requires the presence of an intact basement membrane. An experiment testing this point has not yet been done. It remains to be determined whether the sojourn of the cells in tissue culture plays a part in evoking this phenomenon. The relationship of the phenomenon to kidney tubule formation from dissociated chick embryo nephroblasts[3] *in vitro* or to the development of tubules and glomeruli in rat brain implanted with metanephrogenic rudiments and metanephrogenic mesenchyme recently reported by Grobstein and Parker[4] is as yet not known. Nor is it known from the work done thus far whether the brain plays a part as an organizer or inducer in tubule formation. Be it as it may, the present findings attest further to the utility of the brain as a transplantation site—a fact well documented by workers[5-8] using malignant or embryonic tissues.

We are grateful to Dr. Albert M. McCallen, chief radiologist, and to Mr. Mack Holcomb, therapy technician, of the Veterans Administration Hospital at Coral Gables, for providing equipment and assistance for irradiation of the animals.

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Adaptive Muscular 'Allomorphism'

A new method for quantitatively extracting the sarcoplasm and myofibril proteins from striated skeletal muscle and enabling them to be estimated separately has been described in a recent publication[1]. With the aid of this method, it has been shown (as summarized in Table 1) that various types of atrophy modify more or less drastically the protein composition of the calf muscles in rabbits.

Table 1

Treatment	No. of rabbits	Weight loss (per cent)	Total nitrogen content (mgm./gm. muscle tissue)	Nitrogen components as percentage of total nitrogen			
				Myofibril	Sarcoplasm	Stroma	Non-protein
Controls	50	—	32·3±0·2	57±0·6	25±0·5	8±0·1	10±0·1
Denervation	16	33·1	26·0±0·6	50±0·8	24±0·6	16±0·5	11±0·3
Tenotomy	16	32·5	26·4±0·5	53±1·8	26±1·4	12±0·5	11±0·3
Plaster cast	16	21·0	30·4±0·5	48±1·2	29±0·8	11±0·5	12±0·2

As shown by Table 1, after tenotomy and neurotomy the amounts of total nitrogen, sarcoplasm and myofibril proteins are smaller, but the percentage of stroma proteins is greater than is normally the case. After disuse-atrophy induced with a plaster cast, the total nitrogen content diminished less than after tenotomy or neurotomy, the percentage of myofibril proteins declined and the proportion of sarcoplasm proteins rose. Accordingly, disuse-atrophy reduces selectively the contractile myofibril proteins, an observation I am inclined to interpret as a sign of adaptation to altered working conditions.

I have now completed another series of experiments on rabbits the movements of which were restricted by confinement in a small space. Three groups of adult white rabbits of similar initial age and weight were used as follows. (1) 10 rabbits served as controls and their activity was in no way restricted ; (2) 5 rabbits were kept for 6 months in cages having a floor area of 35 cm. × 70 cm. and a height of 35 cm. ; (3) 4 rabbits were kept for 3 years in cages of the same type as group 2.

All the rabbits seemed healthy throughout and, except as described above, were exposed to identical experimental conditions. While the contribution of age changes to the effects of restricted activity might have been appreciable in group 3, this is unlikely to be so in group 2.

The total nitrogen and the percentages of protein- and non-protein-nitrogen in the thigh muscles were estimated for each animal as described previously[1]. The results are shown in Table 2.

Table 2

Animal no.	Mgm. total nitrogen per gm. muscle tissue	Nitrogen components as percentage of total nitrogen content			
		Myofibril	Sarcoplasm	Stroma	Non-protein
Group 1					
1	32·8	59	26	5	10
2	32·1	58	25	7	10
3	34·0	60	24	6	10
4	32·6	62	23	6	10
5	31·8	57	27	7	10
6	33·1	56	27	6	11
7	32·9	61	23	6	10
8	32·4	60	24	6	11
9	32·7	59	24	6	11
10	33·4	62	22	7	9
Mean	32·8	59	25	6	10
Group 2					
11	33·4	52	31	6	11
12	32·9	52	33	4	10
13	34·1	51	33	6	10
14	32·0	49	34	6	11
15	32·8	53	31	7	10
Mean	33·0	51	32	6	10
Group 3					
16	34·3	40	44	6	11
17	35·2	39	44	6	11
18	32·6	44	41	5	10
19	34·2	41	43	6	10
Mean	34·1	41	43	6	10

This shows that the amount of total nitrogen and proportions of stroma- and non-protein-nitrogen remained practically unchanged. In group 3, moreover, the percentage of myofibril nitrogen—which in the controls was more than twice as high as that of sarcoplasm nitrogen—had declined by about one-third, and the percentage of sarcoplasm nitrogen had increased to about the same level as myofibril nitrogen. Changes with the same tendency were observed in group 2.

Since atrophy invariably increases the proportion of stroma in a muscle, and since it remained unchanged here, this shift cannot have been caused by any kind of atrophy. Nor can pathological factors have been involved. But the muscles in group 2, where age changes cannot have occurred, exhibited changes of apparently the same fundamental type as, only of lesser degree than, the changes observed in group 3. However, the possibility that ageing might produce similar changes in animals that have maintained a constant activity-level throughout their lives cannot be ruled out entirely. Yet irrespective of how the variation arises, the composition of the muscle cell can evidently vary greatly from one normal individual to another.

Changes of this type—for which allomorphosis would seem to be an apt term (ἄλλοσ, other; μορφή, shape)—are due to adaptation of the cell in various circumstances, the degree of activity being a causative factor in the case of the muscle cell. Conceivably, other cells in the organism also undergo allomorphosis.

Hitherto the consensus of opinion appears to have been that the cells in a tissue are of fairly constant composition, and that the proportions of the various cell constituents will change greatly only under pathological conditions. But here it has been demonstrated that, at least in muscular tissue, the composition of individual cells may undergo considerable variations even under normal conditions.

Allomorphosis of the muscle cell must clearly be accompanied by changes in its contractile power. A muscle in which the cells contain a sharply reduced proportion of contractile proteins, and concomitantly an increased proportion of sarcoplasm proteins, cannot be as powerful as an unchanged muscle. Accordingly, because the composition of muscle fibres may vary so greatly, the contractile powers of two muscles cannot be compared solely on the basis of the effective areas of the muscle cross-sections.

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[1] Helander, E., *Acta Physiol. Scand. Suppl.*, 41, 141 (1957).

Salt Requirements in the Tropics during Summer

IN a recent communication, Dahl[1] has stated that a considerable reduction in quantity of salt intake can be made from the existing levels, without any harm to the body. This may, on the other hand, be of great benefit in reducing the incidence of hypertensive cardiovascular disease. The treatment of hypertension by low salt diet is quite well established, but it was not known before that persons on habitually high salt diet are more prone to essential hypertension and its complications. Dahl has predicted that where salt diet exceeds 5 gm. of sodium per day (that is, 12·5 gm. sodium chloride) incidence of hypertension and its complications will be frequent.

This statement may be true of cold and temperate climates where there is practically no loss of salt in sweat and all the dietary salt is excreted in urine (negligible amounts also in fæces and saliva). In the tropics, on the other hand, excretion of salt in sweat is quite appreciable and is higher in those unacclimatized than in those acclimatized. This is because in acclimatized persons the concentration of salt in sweat is comparatively less, due to the influence of adrenal hormones. Therefore requirement of salt is different for the two. When, after living in a hot climate, a person gets acclimatized to heat, his requirement of salt is also reduced.

Our studies have shown[2] that in an environmental temperature of about 101° F. and relative humidity 54 per cent, acclimatized subjects sweating 3–5 l./day could be kept in salt balance on 6·2 gm./day. The requirement of salt has been found to increase proportionally with rise in dry-bulb temperature of the environment. When the maximum day temperature is about 110° F., the requirement of salt has been found to be about 15 gm. for an acclimatized person working for 8 hr. a day. These results have been supported by observations on ratings working in Indian Navy ships for 8 hr. a day in the engine room, where the dry-bulb temperature of the environments was of the order of 110° F.[3], and no case of salt deficiency was recorded on salt intake of 15 gm. a day. Observations in the textile industry in India[4] have also shown that there is no salt depletion in workers working at temperatures up to 86° F. effective temperature for 8 hr. on a normal salt intake of about 15 gm./day.

It has been also found[2] that the physiological requirement of salt is less than that needed for balancing taste in food. If enough salt is taken to satisfy the palate, there is very little likelihood of salt deficiency occurring in the body.

Low incidence of hypertension in India is not due to low salt intake as suggested by Dahl[1]; but is probably due to heavy losses of salt in sweat. The salt content of the Indian dietary varies from 14 to 24 gm. a day from north to south[5], which is more than that of Western countries, where the diet contains 10–15 gm. salt a day[6].

From the foregoing it can be concluded that about 15 gm. of salt (6 gm. sodium) is quite adequate for acclimatized persons engaged in manual work in the tropics, and that for sedentary persons about 6 gm. salt a day is quite enough.

My thanks are due to Prof. D. S. Kothari, scientific adviser to the Minister of Defence, for his interest in this work and permission to publish this communication.

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[2] Malhotra, M. S., Sivaraman, R., and Balkrishan, Ministry of Defence, Defence Science Organization (India) Report No. 3/56 (1956).

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[5] National Sample Survey Depot of Economic Affairs, Ministry of Finance, Government of India Report No. 1, Table Q (1952).

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FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, October 13

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Rationalization of the Avenues of Higher Education for Electrical Engineers".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 6 p.m.—"They Were Kafirs" (Colour films with commentary by H.R.H. Prince Peter of Greece).

Royal Institute of Chemistry, London Section (joint meeting with the Ewell County Technical College Faraday Society, at the Ewell County Technical College, Reigate Road, Ewell, Surrey), at 7 p.m.—Dr. T. W. Farthing: "The Chemistry and Applications of Beryllium".

Monday, October 13—Tuesday, October 14

Society of Chemical Industry, Food Group (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 9 a.m. on Monday and 9.30 a.m. on Tuesday—Symposium on "Texture in Foods".

Tuesday, October 14

Society of Chemical Industry, Agriculture Group (at 14 Belgrave Square, London, S.W.1), at 10.30 a.m.—Plant Constituents Meeting.

Institution of British Agricultural Engineers (at 6 Buckingham Gate, London, S.W.1), at 2.15 p.m.—Mr. A. E. H. Higgins: "Pest Spraying".

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

University of London (at Bedford College, Regent's Park, London, N.W.1), at 5.15 p.m.—Mr. D. L. Pratt: "The Antarctic Expedition" (Stevenson Lecture).*

Society of Chemical Industry, Chemical Engineering Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Dr. K. W. J. Bowen: "Titanium and its Alloys as Materials of Construction for Chemical Plant".

Plastics Institute, London and District Section (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—"Thermoplastic Pipes" (Open Forum).

Wednesday, October 15

University of London (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. D. J. Bell: "Carbohydrate Metabolism".*

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting. Captain F. J. Wylie, R.N.: "Automation in Marine Navigation" (Presidential Address).

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. W. G. Harper and Mr. J. G. D. Beimers: "The Movement of Precipitation Belts as Observed by Radar"; Mr. N. P. Sellick: "Modification of the Structure of a Tropical Cyclone on Traversing a High Plateau".

British Coal Utilization Research Association (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Sir Charles Goodeve, F.R.S.: "Carbon—The Key to Metallurgy" (Seventh Coal Science Lecture).

Eugenics Society (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. Christopher Tietze: "Human Fertility—Statistical Considerations".*

Institution of Electrical Engineers, London Graduate and Student Section (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. J. F. Outram: "Electrical Power Generation and Its Future in Southern England" (Chairman's Address).

Society for Analytical Chemistry, Microchemistry Group (at "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion on "The Role of the Microchemist in Industry" opened by Mr. C. Whalley and Mr. G. Ingram.

Royal Institute of Chemistry, London Section (at King's College, Strand, London, W.C.2), at 7 p.m.—Prof. R. L. Wain: "Systemic Fungicides".

Thursday, October 16

Royal Anthropological Institute of Great Britain and Ireland (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. Herman Lehmann: "Abnormal Hæmoglobins".

University of London (at the Beveridge Hall, Senate House, London, W.C.1), at 5.30 p.m.—Sir Edward Salisbury, F.R.S.: "The Influence of Botany on Health and Disease".* (First of eleven lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on October 21, 23, 28, 30, November 18, 20, 25, 27, December 2 and 4.)

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. D. H. Mathews: "Surface Active Agents and Surface Dressing".

Chemical Society (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Dr. G. Herzberg, F.R.S.: "Spectra of Free Radicals" (Centenary Lecture).

Royal Aeronautical Society, Graduates' and Students' Section (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Major P. L. Teed: "The Fatigue of Aircraft".

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Sir Philip Manson-Bahr, C.M.G., D.S.O.: "The March of Tropical Medicine during the Last Fifty Years" (First Manson Oration).

Thursday, October 16—Friday, October 17

British Interplanetary Society (in co-operation with the Royal Air Force Institute of Aviation Medicine, at the Great Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 9.30 a.m. daily—Space Medicine Symposium.

Friday, October 17

Institute of Rural Life at Home and Overseas (at Friends' International Centre, 32 Tavistock Square, London, W.C.1), at 1.15 p.m.—The Rt. Hon. the Earl de la Warr, G.B.E.: "Developments in Central Africa".*

British Institute of Radiology incorporated with the Röntgen Society (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 2 p.m.—Radiobiology Meeting.

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Air Marshall Sir Owen Jones, K.B.E.: "The Mechanical Engineering of Aircraft Mechanisms" (Presidential Address).

Saturday, October 18

Biochemical Society (in the Chemistry Lecture Theatre, Royal College of Science, London, S.W.7), at 2 p.m.—376th Meeting.

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. K. P. Wachsmann: "African Musicians—a Close-up View of Folk-Music in Uganda".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer in Organic Chemistry; and an Assistant, Grade "B" (with special interests in botany) in Biology at Birkenhead Technical College—The Director of Education, Birkenhead Education Committee, 63 Hamilton Square, Birkenhead (October 15).

Assistant Lecturer (Grade B) in Telecommunications and Electronics—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (October 17).

Principal Scientific Officer (with a degree, preferably with honours, in horticulture or related science, and experience of horticultural crops, particularly those grown under glass) as Head of a new Horticultural Research Department—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (October 20).

Research Physicist (preferably with experience in the use of ultra-high vacuum systems or in the chemical physics of surfaces) in the Department of Physics, for which work will involve electrical measurement applied to the study of surface contamination processes on semiconductors—The Professor of Physics, University of Reading, Physics Research Laboratories, Upper Redlands Road, Reading, Berks. (October 24).

Temporary Assistant Lecturer or Temporary Lecturer (preferably with interests in applied mathematics) in the Department of Mathematics—The Secretary, University College, Gower Street, London, W.C.1 (October 27).

Assistant Lecturer (graduate in chemistry, agricultural chemistry, biochemistry or some similar subject) in the Department of Physiological Chemistry, to deal specifically with dairy chemistry and related biochemical topics—The Registrar, Room 29 (O.R.B.), The University, Reading (October 31).

Assistant Lecturer (with a suitable first degree with a qualification in statistics, and interested in the application of statistical techniques to biological or social sciences) in Statistical Theory and Experimental Method—The Registrar, Wye College (University of London), near Ashford, Kent (October 31).

Lecturer in Agricultural Chemistry (Biochemistry); a Lecturer in Agricultural Chemistry (Soil Science) in the Department of Agricultural Chemistry, Waite Agricultural Research Institute; and Lecturers (2) in Plant Breeding and Genetics in the Department of Agronomy, Waite Agricultural Research Institute, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer in Psychology at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer or Assistant Lecturer in Cytology in the Department of Genetics—The Registrar, The University, Birmingham 15 (October 31).

Professor of Inorganic and Analytical Chemistry at the University of Natal, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, October 31).

Research Assistant (with a first- or second-class honours degree or a research degree in chemistry and an interest in biochemistry), to participate in chemical investigations of fluorine-containing carbohydrates—Dr. P. W. Kent, Department of Biochemistry, South Parks Road, Oxford (October 31).

Scientific Officer (with a good honours degree in botany, genetics or agricultural botany, and preferably postgraduate training in genetics) in the Department of Plant Breeding, to study the genetics and breeding of the tomato with particular reference to disease resistance—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (October 31).

PHYSICIST (with at least a university honours degree in physics with a minimum of two years research experience) IN THE DIVISION OF PLANT INDUSTRY, Commonwealth Scientific and Industrial Research Organization, Canberra, A.C.T., Australia, to join a research team working on the moisture and energy balance of natural surfaces—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 130/329 (November 1).

JUNIOR LECTURER IN PHYSIOLOGY—The Registrar, Trinity College, Dublin (November 3).

SENIOR LECTURER IN ANATOMY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 7).

REGIUS CHAIR OF BOTANY in the University of Aberdeen—The Private Secretary, Secretary of State for Scotland, St. Andrew's House, Edinburgh 1 (November 10).

LECTURER (preferably with special qualifications in algebra) IN PURE MATHEMATICS—Prof. H. Jones, F.R.S., Mathematics Department, Imperial College of Science and Technology, London, S.W.7 (November 15).

RESEARCH STUDENTS AND RESEARCH FELLOWS IN THE SCHOOL OF PHYSICS, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 15).

LECTURER IN INORGANIC AND PHYSICAL CHEMISTRY at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

BROTHERTON CHAIR OF CHEMICAL ENGINEERING in the Houldsworth School of Applied Science—The Registrar, The University, Leeds 2 (January 31).

ASSISTANT LECTURER, Grade B (honours graduate in physics and preferably with teaching and/or industrial experience) TO TEACH PHYSICS up to General Certificate of Education, Advanced Level, and National Certificate standard—The Principal, Enfield Technical College, Queensway, Enfield, Middlesex.

CHEMIST (with a good honours degree in inorganic chemistry or equivalent) IN THE GEOLOGICAL SURVEY DEPARTMENT, Government of Tanganyika, for the analysis of rocks, minerals and ores, and the supervision of junior staff in routine analytical work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD. 105/8/09/T.

COMPUTER (with pure and applied mathematics to G.C.E. advanced level) IN THE PHYSICS DEPARTMENT, for work on rocket and satellite research in the upper atmosphere—The Secretary, University College, Gower Street, London, W.C.1.

LECTURER IN THE PHYSICS DEPARTMENT, Sunderland Technical College, to teach some branch of applied physics to Higher National Certificate or Diploma in Technology level—The Director of Education, Education Offices, 15 John Street, Sunderland, Co. Durham.

LECTURER (preferably with an interest in geomorphology and/or geology) IN GEOGRAPHY in the Training Department—The Warden, Goldsmiths' College (University of London), New Cross, London, S.E.14.

RESEARCH ASSISTANT (graduate interested in electrochemistry), to work on a problem connected with the electro-deposition of metals from solutions containing complexing agents—The Head of the Department of Applied Chemistry, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

SCIENTIFIC OFFICERS (with a first- or second-class honours degree, preferably in physics or electrical engineering), to carry out original research in electronics on a wide variety of interesting problems which arise in nuclear physics and which cannot be solved by present available techniques and equipment—The Senior Recruitment Officer, The Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 2021/34.

SENIOR LECTURER (with a specialized knowledge of microbiology with particular reference to industrial processes, and actively interested in research) IN THE DEPARTMENT OF BIOLOGICAL SCIENCES—The Registrar, Bradford Institute of Technology, Bradford 7.

SENIOR RESEARCH WORKER (with a Ph.D. degree or equivalent research experience) IN THE PHYSICS DEPARTMENT, for upper atmospheric research (using Skylark rockets)—The Secretary, University College, Gower Street, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Building Research Station Digest No. 112: Some Recent Work. Pp. 12. (London: H.M. Stationery Office, 1958.) 3*d*. [58

The Education and Training of Student Apprentices in Electrical Engineering: a Report of the Joint Committee on Practical Training in the Electrical Engineering Industry. Pp. 26. (London: Institution of Electrical Engineers, 1958.) 2*s*. [68

Report of the Hydrographer of the Navy for the year 1957. Pp. 18. (H.D. 510.) (London: Admiralty, 1958.) [68

The Utopist Tradition in English Education. By Prof. W. H. G. Armytage. (Sixth Vaughan Memorial Lecture.) Pp. 16. (Doncaster: Doncaster Grammar School, 1958.) 1*s*. 3*d*. [68

World Power Conference. Annual Report 1957. Pp. 20. (London: Central Office of the World Power Conference, 1958.) [68

Cancer Death Rates by Site, Age and Sex, 21 Selected Countries, 1951–1953. By R. A. M. Case and Joyce L. Harley. Pp. xv+64. (London: Chester Beatty Research Institute, Institute of Cancer Research, Royal Cancer Hospital, 1958.) [68

Privy Council. Medical Research Council Memorandum No. 36: The Determination of the ABO and Rh(D) Blood Groups for Transfusion. Pp. vi+46. (Revision of War Memorandum No. 9.) (London: H.M. Stationery Office, 1958.) 3*s*. 6*d*. net. [68

Forestry Commission. Leaflet No. 6: Honey Fungus. Pp. 9. 6d. net. Leaflet No. 42: Woodpeckers in Woodlands. By C. E. Palmar. Pp. 12. 1*s*. net. Leaflet No. 43: Keithia Disease of *Thuja plicata*. Pp. 5. 1*s*. 3*d*. net. (London: H.M. Stationery Office, 1958.) [88

National Museum of Wales, Cardiff. Paper and Its Uses: Handbook to a Temporary Exhibition, June–December, 1958. Pp. 20+8 plates. (Cardiff: National Museum of Wales, 1958.) 1*s*. [118

University College of Wales, Aberystwyth. Welsh Plant Breeding Station. Report 1950–1956. Pp. 171. 7*s*. 6*d*. Leaflet Series No. 6: The Aberystwyth Strains of Grasses and Clovers. Pp. 18. 2*s*. 6*d*. (Aberystwyth: Welsh Plant Breeding Station, University College of Wales, 1958.) [118

About Vitreosil: a Reference Handbook. Pp. 44. (Wallsend: The Thermal Syndicate, Ltd., 1958.) [138

Current Medical Research: a reprint of the articles in the Report of the Medical Research Council for the year 1956–1957. Pp. v+54. (London: H.M. Stationery Office, 1958.) 3*s*. 6*d*. net. [138

London and Home Counties Regional Advisory Council for Higher Technological Education. Bulletin of Special Courses in Higher Technology, including Management Studies and Commerce, 1958–9. Part 1: Autumn Term. Pp. 122. (London: London and Home Counties Regional Advisory Council for Higher Technological Education, 1958.) 3*s*. [138

Report of the City and Guilds of London Institute for the year 1st October, 1956, to 30th September, 1957. Pp. v+118. (London: City and Guilds of London Institute, Gresham College, 1958.) [138

Forestry Commission Bulletin No. 14: Forestry Practice: a Summary of Methods of Establishing Forest Nurseries and Plantations with Advice on other Forestry Questions for Owners, Agents and Foresters. Seventh edition. Pp. vi+93. (London: H.M. Stationery Office, 1958.) 5*s*. 6*d*. net. [138

Report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory (period 1957 April 1 to 1958 March 31). Pp. 13. (Herstmonceux: Royal Greenwich Observatory, 1958.) [138

Other Countries

United States Department of Commerce: Coast and Geodetic Survey. Publication 63-1: Gravity Control Measurements in North America. By Donald A. Rice. Pp. 23. 15 cents. Technical Bulletin No. 1: Aerotriangulation Adjustment of Instrument Data by Computational Methods. By William D. Harris. Pp. i+4. 5 cents. Technical Bulletin N. 2: Tellurometer Traverse Surveys. By Hal P. Demuth. Pp. i+8. 15 cents. (Washington, D.C.: Government Printing Office, 1958.) [58

Province of Quebec, Canada. Department of Mines: Laboratories Branch. A Chemical Study of the Peats of Quebec. 11: Saint-Hyacinthe Peat Bog, Electoral Districts of Saint-Hyacinthe and Bagot. 12: Saint-Blaise Peat Bog, Electoral District of Saint-Jean. By J. Risi, C.-E. Brunette, R. Cloutier and H. Girard. Pp. ii+32. (P.R. No. 350.) (Quebec: Department of Mines, Laboratories Branch, 1958.) [58

Serving the Caribbean: The Caribbean Commission—What It Is, What It Does. Pp. 24. (Trinidad: Central Secretariat, Caribbean Commission, Kent House, 1958.) [68

The Abstracts Journal: Metallurgy. No. 9, 1957. Translated from the Russian. Pp. 55. Issued bi-monthly. One volume per annum consisting of 6 issues and containing approximately 100 pages per issue. Annual subscription: libraries, institutions and individuals 20 dollars (140*s*.); to members of Co-operating and Sponsoring Societies of *Acta Metallurgica*, 10 dollars (70*s*.). (New York and London: Pergamon Press, 1958.) [68

The Physics of Metals and Metallography, Vol. 4, No. 1, 1957. Translated from the Russian. Pp. 159. Issued bi-monthly. Two volumes per annum consisting of three issues each and containing approximately 150 pages per issue. Annual subscription: libraries, institutions and individuals 30 dollars (210*s*.); to members of Co-operating and Sponsoring Societies of *Acta Metallurgica*, 15 dollars (105*s*.). (New York and London: Pergamon Press, 1958.) [68

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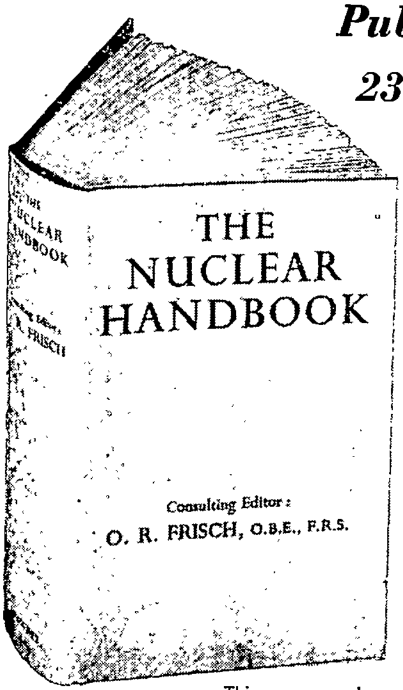

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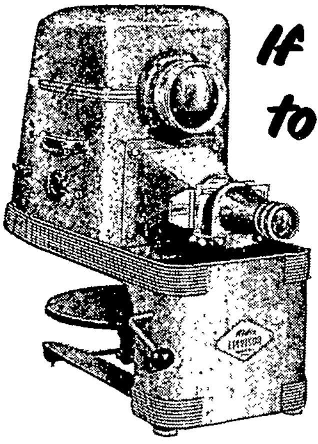

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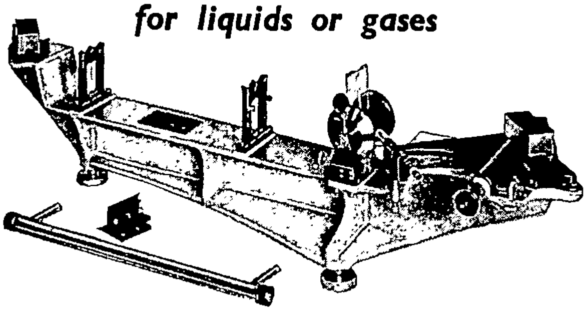

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EDUCATION: AN INVESTMENT FOR THE FUTURE

THE correspondence between Sir Philip Morris, chairman of the National Advisory Council on the Training and Supply of Teachers, and the Minister of Education, on the supply of teachers in Britain in the 1960's, was published* shortly after the statistics given in the Ministry's annual report for 1957 had indicated that, so far from the 'bulge' flattening out, a new peak was likely in 1968, and had again stressed the need for a considerably larger number of teachers of mathematics and science to deal with the increasing number of children in the secondary schools. In his letter, dated July 16, Sir Philip sets forth the Council's views on the situation since its fifth report, on three-year training for teachers, was published in September 1956, in the light of this probable increase in the number of children in the schools; and he gives a revised estimate of wastage of teachers, and the actual number of candidates offering themselves for training.

On wastage, the Council is inclined to attribute the sudden increase mainly to an increased loss of women teachers through earlier marriage and child-bearing, and it has now provisionally adopted the conservative assumption that the annual increase of teachers in Britain in the future will be either 6,000 or 5,000. To obtain the objective of reducing sizes of classes to a maximum of forty in the primary and thirty in the secondary schools by 1968 now appears likely to require 326,000 teachers instead of the 299,000 previously assumed, and on the higher estimate of wastage the number of teachers likely to be available is 282,000. The Council concludes that if the staffing objectives are to be attained, the short-fall of teachers in January 1968 is unlikely to be less than 34,000. The present position as regards the supply of candidates offering themselves for training is regarded as satisfactory and likely to remain so in 1960 and to an increasing extent in later years.

Nevertheless, the Council emphasizes the need for new decisions and urgent action to maintain the annual rate of increase in the total number of teachers available by 1968 at the higher level now seen to be required. Nothing less, it believes, than an annual output of 12,000 teachers from the three-year course will suffice to maintain the present annual output of about 10,000 teachers and make good over five years the loss of 10,000 teachers in the year of intermission. Accordingly, the Council recommends provision of 16,000 additional places to bring the capacity of the training colleges to 36,000 places; it is regarded as being of the utmost importance that these places should be available by the autumn of 1962. It is suggested that, with this expansion, the present pattern of teacher training should be re-examined. Particularly in planning new colleges and the expansion of existing colleges, attention should be given to the optimum size of a college for economic working, and the continuation on their present basis of the existing specialist colleges should be reconsidered. As regards location, colleges should be in, or readily accessible to, a university town or similar educational or cultural centre, and the general spread of colleges should take into account the existence of areas where the authorities have difficulty in recruiting enough teachers.

Even in this situation, however, the Council is not prepared to recommend postponement of the introduction of the three-year course from 1960 to 1961, and it believes that by taking urgent action on the lines suggested the position up to 1968 can be made reasonably satisfactory if a building programme of this size is put in hand in time. In acknowledging the letter, the Minister said that he was considering the Council's advice as a matter of urgency and on September 21 he announced that 12,000 new places would be provided in the training colleges to be completed by 1962 at a cost of about £15 million.

It is this note of urgency that is needed at all stages if the nation is to receive the full return from the increasing effort now being devoted to education. Notably is this true of technical education. Although a pamphlet recently issued by the Central Office of Information and the Ministry of Education fully supports what Sir Willis Jackson said at Glasgow as to the need for industry effectively to discharge its responsibilities to enable employer and employee, and through them the nation, to gain the full benefit, something more than the exhortation and guidance given in that pamphlet may be required to make industry, and particularly the small firms, take an adequate part.

It is not sufficiently realized yet that the bulk of technical training is given, and will continue to be given, in factories and offices. Most technical, much technological, and all apprenticeship training is in fact based on industry; the Ministry of Education and the local education authorities can only provide the framework of a system of technical education. Moreover, for every additional technologist, it is necessary to produce six additional supporting technicians or craftsmen—the latter mainly by the apprenticeship system—if there is not to be waste of highly skilled man-power.

It is from this point of view that grave doubts exist as to whether we are yet in sight of getting the full return from the Government's proposals, and whether by themselves they are adequate, particularly in view of the marked indifference of the smaller firms and the poor quality of the technical training they give. It is partly a question of economics, of the measures to be taken both to organize the supply of recruits and teachers, and equally to see that the most effective use is made of our existing institutions and man-power, and to ensure that the man-power once trained is not wasted. Much of the attention given to education at the recent British Association meeting at Glasgow might be regarded as concerned with these aspects: it underlies, for example, the discussions on education in a technological age, and was much in Prof. W. R. Niblett's mind in discussing the value, function and opportunities of residential halls in the modern university.

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* The Supply of Teachers in the 1960's—Correspondence between the Chairman of the National Advisory Council on the Training and Supply of Teachers and the Minister of Education, July, 1958. Pp. 12. (London: H.M. Stationery Office, 1958.) 9*d*. net.

In the former discussion, Prof. F. A. Vick's plea for greater flexibility in courses has a firm economic basis, as tending to reduce the risk of expensive failures. Experience at the University College of North Staffordshire, he pointed out, shows the value of experiment and the possibilities of doing more to break down the barriers between the arts and the science sides and to encourage the wider outlook which industry, for example, increasingly demands of its entrants. It is interesting to recall in this connexion that in a recent broadcast talk in which he discussed the teaching of undergraduates in the humanities, Prof. P. H. Nowell-Smith, professor of philosophy in the University of Leicester, insisted that some study of science should be compulsory for all such students. For good or ill, our lives, both public and private, are, in fact, very much influenced by scientists, and if intelligent decisions are to be made, those making them must have some understanding of what science is.

That, in other words, is a plea for more effective teaching on the grounds of efficiency, and nothing less underlies the present developments and experiments in halls of residence. Prof. Niblett is convinced that this activity is worth while from its contribution to the quality and character of the graduates; but it can still be open to experiment as to how best the educational contribution of a good hall of residence can be made, and whether we have yet found the best economic answer from the point of view of investment in buildings, quite apart from that of man-power. This aspect was emphasized even more markedly at Glasgow in a provocative paper, "The Economics of Education", by J. Wiseman, and it is also the theme of a recently published book by J. Vaizey on "The Costs of Education"*.

Mr. Wiseman is concerned first with the volume and nature of the resources devoted to education and with the most efficient use of those resources, postulating individual freedom of choice. He argues that we have accepted the role of the State as the provider of general education too uncritically, and that the place of educational provision in a free society needs re-examination. While his proposals are intended to achieve a more satisfactory allocation of our resources to education and at the same time meet better both the desires of parents and the interest of the community in education, they are too revolutionary and controversial to facilitate that steady and urgent improvement in matters of detail which at present seems to be the first need. The responsibilities of the State would still include, in his proposals, legislation requiring school attendance up to some minimum age and the maintenance of minimum standards; but for the rest, the contribution of the State would be limited to the provision of 'education vouchers' valid at any 'approved' school which the parents selected. The central government would accept sole responsibility for the financial share of the State, but local authorities would be allowed to charge fees if they wished and could. In the creation of new educational facilities, private building would be encouraged and public activity limited to what was necessary to make the system work.

Mr. Wiseman puts a point of view that merits consideration and might yet offer the soundest objective; but the immediate issues are too urgent to permit the long debate that would be necessary to secure the general agreement required before a policy based on his views could be formulated. Mr. Vaizey's study is much more practical. It provides in the first place the hard facts about the trend in educational expenditure in the United Kingdom since 1920. Moreover, as Prof. R. M. Titmuss observes in a foreword, the classification of this material by categories of resources, kinds of education and classes of beneficiaries allows Mr. Vaizey to comment trenchantly on current techniques of central and local control over expenditure, and the role of the teaching profession in the administrative structure. He sees, for example, a very strong case for relaxing the Ministry's detailed financial control.

Beyond this, existing weaknesses in the educational system of Britain, on some of which Sir Hugh Beaver commented forcefully earlier this year, are again displayed and pertinent questions about the rate of investment by the State in education are suggested; and the criteria discussed by which the real cost and value of education are to be judged—whether at the level of advanced scientific and technological training, or at that of primary and secondary education in the schools. Mr. Vaizey indicates the dangers which need particular attention and points out which investment is likely to bring a most effective return. Evidence may be found to support Mr. Wiseman's argument; but the great value of the study is the assistance which it brings to the identification of educational priorities. The determination of such priorities is a first duty if limited resources are to be wisely and efficiently expended, and for this such a factual survey is essential.

Even a few of Mr. Vaizey's broad conclusions suffice to indicate the need and value of a study in which the concept of cost is related to the national income. Until 1950, for example, expenditure, as ordinarily understood, on education involved a lower proportion of the national income than in most pre-war years; in 1955 it was less than in 1932, if such social expenditure as school meals, milk and the health service is excluded from the calculation. Even at 2·8 per cent, it compares with 2·2 per cent in the 1920's, 2·6 per cent in 1932 and 2·2 per cent in 1939; and including capital expenditure, the figure of 3·4 per cent compares with 2·7 per cent in

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* The Costs of Education. By John Vaizey. Pp. 256. (London: George Allen and Unwin, Ltd., 1958.) 30s. net.

1930 and in 1938. Whereas in 1920 the central government provided 50 per cent of the revenue, local authorities 42 per cent and 8 per cent came from fees, in 1955 the corresponding figures were 58, 36 and 6 per cent.

Expenditure on public education in Britain rose from £84·6 million in 1921 to £168·1 million by 1946 and £410·6 million in 1955; but since 1945, rising expenditure has no more than kept in step with rising productivity. Over this period, while the proportion expended on primary education decreased from 42·8 to 30·7 per cent, that on secondary education increased from 17·7 to 22·3 per cent, on the universities from 5·2 to 8·2 per cent; that on further education remained constant at 6·0 per cent (after a decrease to 4·7 per cent in 1948 and a peak of 6·2 per cent in 1953) and that on the training of teachers rose from 0·4 per cent to 1·3 per cent. Between 1920 and 1955 the universities doubled their student population, and at 1948 prices their expenditure rose from £5·2 million to £25·4 million, with a doubling of expenditure in the seven post-war years and a 50 per cent increase in real terms, chiefly in consequence of the rising cost of scientific research and the greater amount undertaken. Moreover, the finding that university fees only represent one-seventh of the true cost has considerable bearing on current discussions on university awards.

Mr. Vaizey's study goes a long way towards supplying the perspective in which to judge current proposals for the expansion of particular aspects of education, such as the teachers' training colleges, the technical colleges and the universities, and also the soundness of the criticism advanced of such proposals, and of existing institutions and policy. In particular, it is apparent how important it is that no opportunity should be overlooked of ensuring both that the nation's steadily rising investment in education is wisely expended, and its distribution so timed as to secure the fullest return; and also that there is no waste of the trained man-power that results. Even when the utmost care has been taken to avoid waste of skilled man-power and to ensure that it is effectively deployed and supported with the technicians and ancillary workers and equipment necessary to ensure full efficiency, the production of the full number of scientists and technologists which are required to maintain Britain's industrial productivity will tax our resources to the utmost. No less care must be taken, therefore, to see that standards and conditions of teaching are such as to ensure the utmost efficiency, and to secure the fullest possible co-operation from industry and commerce, where the responsibility in what Sir Willis Jackson has rightly insisted is a partnership begins. In so far as the backwardness of particular firms or sections of industry in co-operating contributes to the waste of national resources and investment in education, the responsibility should be made plain, and if possible policy concerted to put the consequent cost where it properly belongs.

THE EDUCATION OF ADULTS

Adult Education

A Comparative Study. By Prof. Robert Peers. (International Library of Sociology and Social Reconstruction.) Pp. xiv+365. (London: Routledge and Kegan Paul, Ltd.; New York: Humanities Press, 1958.) 35*s*. net.

TWO years ago Prof. R. Peers retired after serving as head of the extra-mural department of the University of Nottingham for thirty-five years. He was then elected to a professorial research fellowship, and has since renewed acquaintanceship with various adult education movements in different countries, brought his knowledge of others up to date, pondered on the experiences of a life-time spent in adult education, and written this book. By clever design or skilfully arranged accident, the sub-titles on the dust-cover and fly-leaf are different. One refers to the work as a comprehensive study of adult education; the other to a comparative study. The author can fairly claim that he has written both.

The first part refers to the early origins of adult education in Great Britain and faithfully relates these to their social, economic, political and religious impulses. Then follows an account of the present characteristics of adult education in Britain to-day. This, as Peers freely admits, is almost entirely connected with the liberal adult education movement which has grown up under the auspices of organizations like the Workers' Educational Association and university extra-mural departments. Little or no mention is made of those informal activities which contribute so much to educational experiences in community life.

Peers then goes on to discuss the kind of student who makes up the liberal adult education movement and follows with a survey of the possibilities of adult learning. Foreign students of the British educational system who are bemused by the private nature of our public schools will be equally bewildered to learn that the Workers' Educational Association (and university extra-mural departments) to-day provide comparatively little for manual workers; members of trade unions are inadequately represented in their classes, and unskilled workers scarcely at all. The student body is largely middle and lower middle class.

The survey of adult learning is more concerned with the 'when' of learning than the 'how'. Peers's review shows how little is known of the learning process in adults and, after discussing the meagre information which does exist, indicates how his colleagues in the field could collect information which, when collated, might make considerable differences to the way in which adult education classes are conducted both inside and outside university walls. Although not agreeing with the zealots who believe that all adults are capable of continued education at an advanced level, Peers produces certain experimental evidence to support his own belief that, even among those who do not possess a high grade of generalized academic ability, there are specific abilities which can be developed throughout the life of the individual and which are perhaps no less important than those qualities of mind which have hitherto been given pride of place. Perhaps, inadvertently, Peers has again pin-pointed the need for investigations into the learning processes of adults of both sexes at different times of their lives and with different full-time educational backgrounds.

The comprehensive nature of this review of liberal adult education in Britain is rounded off with sections dealing with the place of tutors and the methods used in adult education. These bring out the relatively low status still accorded to extra-mural departments in many British universities; this may be connected with the fact that a number of extra-mural departments are still far from clear as to their own role either as a university department or in the educational movement as a whole.

The comparative study begins with a brief review of adult education in the Scandinavian countries, certain British Dominions and Japan; there is also an account of the not-too-successful attempts to form international organizations for adult education. Through his recent visits, Peers has gained up-to-date knowledge of adult education movements in the United States and Germany and rightfully devotes considerable attention to them. He suggests that in the United States the university extension movement is too all-embracing and popular; in Germany the universities are too academic and remote from the world at large to be of use to the ordinary man. With the British traditional liberal adult education movement based on the universities it is difficult to equate other systems with that of Britain; an Indian making comparative studies might come to different conclusions from those who have been steeped in the British way.

The concluding sections of the book contain the author's philosophy of adult education for a modern age. To this all-too-brief chapter one turns with full expectation of gaining much from the mature reflexions of one who has given so long and so generously to adult education. Nor is one disappointed. In contrast to the social and economic impulse which gave purpose to the early adult education movement in Britain and which helped to bring about many reforms in the national education system, Peers believes that the future of adult education will no longer lie in providing belated opportunities for learning which the community has failed to provide at the proper time. Instead, the purpose of continued education in adult life is seen as a necessary part of the education of the citizen of the democratic State, "that part which *belongs* to adult life because it cannot be undertaken at any earlier stage". Adult education should, therefore, be available for all who are capable of profiting by it, and Peers is undoubtedly right in stating that this number is very much greater than those who are taking advantage of the opportunities available at present.

Whether he rightly appreciates the part which existing adult education organizations will play in the educational activities of future adults remains to be seen. Despite the insidious onset of Admass, the extension of television has led to 'full houses' at theatres where ballet and opera are performed. Current political and social problems are discussed by more people in industrial canteens than many who are not daily in touch with the working man are prepared to believe. Many industrial education officers are also aware of the extreme suspicion which intelligent shop-floor workers have of any movement which savours of the academic or institution. Using the interests created by television, the extension of adult education may take place most freely in conjunction with the growth of more informal activities provided in places where men work or spend their leisure. In this, science must have a much greater place than hitherto; this can only come about if more of our adult educationists are themselves men of science. Whatever the means of the spread, there is little doubt that all who are concerned with the true ends of adult education will gain from Peers's all-too-short account of the future in adult education. They will also benefit from a remarkably well-written book which is both comparative and comprehensive.

T. H. HAWKINS

THE HAND AND HUMAN NATURE

The Human Hand

A Psychological Study. By Géza Révész. Translated by John Cohen. Pp. xii+138. (London: Routledge and Kegan Paul, Ltd., 1958.) 21*s*. net.

AS a leading theme for the attention of psychologists interested in trying to relate the highest attributes and capacities of man to their biological foundations, the human hand presents notable advantages. It is indeed surprising how little serious work has been devoted to it. Along with high-grade sensory functions and a massive reorganization and development of the brain, it is a central feature of the sequence of adaptations which eventually placed man in a position in many respects dominant among animals. It is at once an important sense-organ and a tool of far-reaching potentiality. But at the same time it crops up in a host of interesting, and sometimes suggestively odd, connexions in myth, religion and custom, and in artistic and symbolic expression. The activities of this one part of the body are thus embedded in every level of human behaviour, and to trace in continuous fashion their inter-relations could scarcely fail to illuminate more general problems of human nature.

Yet up to the present, helpful contributions to the subject have been limited in scope to special aspects. Sir Charles Bell seems to have found insufficient material to fill his "Bridgewater Treatise" of 1833, for it contains much on other topics. Later anatomists whose vision extended outside the dissection-room, notably Wood Jones and Elliot-Smith, did much to elucidate the role of the hand in human evolution, the latter especially in relation to the emergence of complex cerebral organization and refinements of the distance-receptors. Its connexions with the origins of language, including as they do many puzzling issues concerned with handedness and cerebral dominance, remain obscure despite a lot of attention from clinical neurologists and others during the past century. Studies of gesture language have tended to oscillate between pure description and wild speculation. On a rather different plane there have been persistent attempts to formulate and generalize intuitive connexions between the physical form of the individual hand and the character and temperament of its owner. An absence of coherent scientific structure in such speculations makes decision as to their merits more than difficult.

It was to direct attention to this fascinating and potentially rich field that the late Prof. G. Révész wrote this engaging little book, now skilfully and sympathetically translated by Prof. John Cohen. Révész's own interest grew out of his studies in tactile perception and in the artistic capacities of blind people. But, apart from a rather strange failure to refer to the forms of breakdown of the perceptual and executive powers of the hand produced by cerebral disorder, he touches on most aspects of the subject. Inevitably in so brief a work his touch is light. There are chapters on the comparative and developmental aspects ; these suffer somewhat from lack of reference to the central nervous functions without which the hand itself would be inert and useless. Some varied points concerned with the general significance of the hand in human life are interestingly sketched, and the bulk of the book is devoted to discussion of specific functions such as perceiving, manipulating, plastic activity and expression. The book ends with a short and stimulating chapter on the magical significance of the hand. Prof. Révész is never dull, if not always satisfying. He has sketched a field worthy of a much larger work. There are a number of nice pictures. Perhaps this is why a guinea has had to be charged for scarcely forty thousand words of text.

R. C. OLDFIELD

SCIENCE IN AFRICA

Science in the Development of Africa

A Review of the Contribution of Physical and Biological Knowledge South of the Sahara. By Dr. E. B. Worthington. Pp. xix+462. (London: Commission for Technical Co-operation in Africa South of the Sahara, and the Scientific Council for Africa South of the Sahara, 1958.) 30*s*. net.

TWENTY-FIVE years ago many of those concerned with developments in Africa felt that progress was impeded because there was no overall account of conditions in the various territories. One result was Lord Hailey's "African Survey", first issued in 1938 and fully revised in 1956. Dr. Worthington, also in 1938, produced his "Science in Africa", designed to supplement Lord Hailey's volume. The book now issued is a revised, rewritten and expanded successor to the earlier work.

Particularly since the end of the War in 1945, organizations have grown up to foster co-operation in the African territories. Dr. Worthington was the first secretary-general of the Scientific Council for Africa South of the Sahara, and it is on behalf of that Council and of the Commission for Technical Co-operation in Africa South of the Sahara that this book is issued.

Parallel with the great political developments which have taken place in Africa since 1938 the scope of scientific work has increased immensely, so it was clearly a monumental task that Dr. Worthington undertook when he attempted to condense all this into a book of less than four hundred pages of text. Only a man with his experience of Africa, as a research worker and as an administrator of science, could have done this. There is some account of every major, and many a minor, project in the physical and biological sciences in all the territories concerned. In all the cases in which I have any knowledge the information given, so far as it goes, is accurate and carefully checked, and what might have been a list of disconnected statements is turned into a readable story. This should be of considerable value to anyone who wants to obtain a bird's-eye view of scientific developments in the continent of Africa.

We are shown how scientific organization has increased, facilities have improved, and research has developed. At times the reader may feel that with still a comparatively small number of investigators in the field or at the bench, the organization is somewhat top-heavy, and it is difficult not to sympathize with the view often expressed by actual research workers that some of the resources expended to encourage co-ordination would be better used to support original work. Also, while there have been noteworthy applications of some of the discoveries, science has still made little contribution to the increase in productivity in many of these countries which must take place if the ambitious plans of politicians are ever to be implemented. The hope of those who set up the Scientific Council was that, by international co-operation, these developments might be accelerated.

The reader who will be most disappointed with this book is the one with a specialized knowledge of some particular problem. Dr. Worthington has had to cover such a wide field that many subjects are inevitably given sketchy and incomplete treatment. Numerous examples could be quoted. For example, though there has been a great deal of research on poultry-keeping in the tropics, here we find only ten lines of very general information in the section "Other Kinds of Stock", and two lines on Newcastle disease in the section on "Virus Infections". In another context the importance of medical training of indigenous people is referred to, but there is no mention of the ambitious medical school at Dakar, allied to the Universities of Bordeaux and Paris, or of the teaching hospital at Ibadan in Nigeria, though this must be the largest and best equipped building devoted to scientific work in the African tropics. Such deficiencies do not, however, greatly detract from the value of the book to the reader who wants only a general picture, and the bibliography may help those who wish to study particular topics more fully.

Dr. Worthington believes, as do the members of the bodies which sponsor this work, in inter-territorial co-operation. He concludes (after briefly sketching the progress of scientific work) with these words: "In the 1950's the territorial and regional barriers are breaking down through inter-African co-operation. By the 1960's we may see African science taking its full and proper place in the development of the continent". While echoing this final hope, there would seem to be some doubt as to whether the barriers are in fact breaking down. Elsewhere Dr. Worthington mentions that nationalism and tribalism, by dividing larger colonial territories into smaller self-governing States, may discourage scientific co-operation. I am inclined to think that these inevitable changes may not, in the long run, be very important. African scientific development has reached a stage where co-operation cannot be forced on it, any more than it could on the various countries of Europe. Some territories "South of the Sahara" have as much in common with countries in Asia or America as with their neighbours. Dissemination of information about scientific work in Africa, as in other areas, is now probably best through the normal international channels. Artificial regionally based organizations may well be obsolescent.

This revision, after twenty years, of Dr. Worthington's survey of 1938, is perhaps of greatest value in showing that science in Africa is growing up. As the countries of Africa take their place in the international field, specifically 'African science' is seen to be something of a myth, and we have now to deal simply with science—which is now being studied in the African continent.

KENNETH MELLANBY

TROPICAL FOREST ARCHÆOLOGY

Archæological Investigations at the Mouth of the Amazon

By Betty J. Meggers and Clifford Evans. (Smithsonian Institution: Bureau of American Ethnology, Bulletin No. 167.) Pp. xxviii + 664 + 112 plates. (Washington, D.C.: Government Printing Office, 1957.) n.p.

THE authors of this report studied an extensive area consisting of the islands of Marajó, Mexiana and Caviana at the mouth of the Amazon, and the territory of Amapá which lies north of it. It is an area in which living conditions are far from pleasant and transport can be excessively difficult. The natural conditions are a great hindrance to archæological work, but the authors overcame them with great determination.

The area was previously known only for the remarkable pottery burial urns and associated objects belonging to what is now called the Marajoara Phase on Marajó Island, whence have arisen theories that the island was a centre of cultural development, radiating its influence far and wide. The expedition proved that the truth was the precise opposite; not only were seven more lowly phases of culture shown to have come fully fledged into the area and to have maintained themselves at their initial level until absorbed or displaced by the next invader, but also the more elaborate Marajoara Phase was demonstrated to have arrived similarly and at once embarked on a process of degeneration, ending up at the same level as the others. Most of the objects belonging to the living tribes of the lower Amazon are very perishable —wood, gourds, feathers and so on—and they soon disappear when discarded, leaving only pottery and rare objects of stone. The same conditions undoubtedly existed in antiquity, and the present work is of necessity based mainly on pottery, but the application of the most rigorous and painstaking methods of analysis enabled much to be learnt. In this connexion attention must be directed to a misprint in Fig. 141 which vitiates an argument, the pottery titles Inajá Plain and Camutins Plain having been interchanged.

The main outlines of the authors' conclusions have been known for some time to specialists through short communications, and what this report does is to set out the evidence fully and state some of its wider implications. Some years ago, Julian Steward gave strong support to the theory that a tropical forest could only support a culture on what he called the 'Tropical Forest' level, similar to that of the living forest tribes, and that a more advanced culture coming in would, owing to limitations of food supply, decline to tropical forest level. The authors see the behaviour of the various cultural phases, and particularly the decline of the Marajoara Phase, as a triumphant vindication of this theory. In addition, they have developed an ingenious method of building up a time-scale by means of the rate of accumulation, not of deposits but of potsherds; they themselves realize the limitations of this, but it seems to work on the whole, and it gives an indication that the earliest pottery-making tribes in the islands cannot have arrived before about A.D. 700, whereas the mainland of Amapá was not occupied by such people until much later. A further conclusion is that the archæological record does nothing to support the theory that the tropical forest pattern of culture spread from the north down the Guiana coast and up the Amazon. By a study of the distribution of traits the authors have indicated probable sources for the various phases, and in particular they believe that the Marajoara Phase originated in the Andean areas of Ecuador and Colombia.

A point which has already involved the authors in controversy is their contention that the way in which a tropical forest environment limits a culture constitutes a law of universal application, not confined to the area where they have applied it so successfully. The Maya appear to be a notable exception, and although Meggers has maintained that they did not develop their high civilization in the tropical forest part of their habitat, many Maya specialists disagree, and whatever their origin, the Maya succeeded in maintaining their culture there for a long time. Parts of the Old World, such as Nigeria and south-east Asia, would repay further study in this connexion. G. H. S. BUSHNELL

BIRDS IN SPAIN

Portrait of a Wilderness

The Story of the Coto Doñana Expeditions. By Guy Mountfort. Pp. 240 + 59 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 30*s*. net.

MANY people saw and enjoyed Mountfort's beautiful colour film, "Wild Spain". His present book gives a report on the expeditions to Coto Doñana, where the film was made. There were three expeditions (in 1952, 1956 and 1957), the last one being the largest and best equipped. All of them consisted of qualified students and experienced photographers, and since the main interest was in birds, the ornithological staff of the expeditions was well selected, the names of the members speaking for themselves.

Coto Doñana, a wonderful spot on the Atlantic coast of Andalucia, is truly a bird paradise of incomparable beauty and richness of bird and animal life. Since the fifteenth century it has been known as a famous hunting ground of the kings of Spain, and, owing to the efforts of its successive owners, it has preserved its unique character of a wilderness unaltered and undevastated by man, where plants and animals live freely and undisturbed by modern civilization. In addition, it lies in a very favourable part of the continent of Europe from the point of view of natural history phenomena, and this makes it one of the most interesting nature preserves in Europe. During the spring migration the numbers of birds and species represented are incomparable. Some rare birds breed there, others appear periodically during the migration.

The aims of the expeditions were to study birds, to photograph them, as well as to collect materials referring to other zoological groups. In this respect they were successful also, and the collections made will add valuable scientific information about this area. The birds, however, are the main objective of the present book and they are described with love, zeal and pure scientific exactitude. It is the author's great merit that, writing on scientific matters and observations, he does so not only in very simple and readable manner but also with humour and much interest. Consequently, his book is by no means a dry and scientifically overloaded account digestible by specialists only. On the contrary, it will be greatly enjoyed by everyone interested not only in birds but also in general zoology, geography, folklore and so forth. These values, together with the author's literary abilities, have resulted in a beautiful book which will be read by everyone, not only with profit but also with great pleasure.

Special mention must be made of the photographs illustrating the text. Most of them were made by Eric Hosking, a name that speaks for itself. All are at the highest level of technical and ornithological skill and talent—they are simply wonderful. The ornithologists of the expeditions were fortunate enough not only to watch some very rare species but also to photograph and film them. Photographic material collected by the expeditions contains pictures of species that have never before been photographed. Some of these unique scientific documents are included into the book, others could be seen on the colour film already mentioned.

Many black-and-white drawings by Penelope Mountfort and the author himself add much charm to this tastefully edited and executed book. It should not only be recommended; it certainly will be a desirable and greatly enjoyed acquisition in every library. W. RYDZEWSKI

ELECTRODYNAMICS OF MOVING MEDIA

Electromagnetism and Relativity with particular reference to Moving Media and Electromagnetic Induction

By Prof. E. G. Cullwick. Pp. xxiii+300. (London and New York: Longmans, Green and Co., Ltd., 1957.) 63*s.* net.

THERE is a need in the literature, the author reminds us in the preface to his book, for a systematic study of the electrodynamics of moving media. The title of the volume under review leads one to expect that this need would be met by Prof. Cullwick's book. Unfortunately, it disappoints, and leaves the impression that the author has been primarily concerned with elucidating a familiar theory by a number of isolated problems some of which are now classical.

The book does not lack general interest; but certain misleading and controversial conclusions do much to detract from its value as a reference book. The book is divided into four parts and it will be convenient to deal with each in turn. The first part is concerned with the uniform rectilinear motion of charged particles and moving media, and includes chapters on special relativity and the relativistic transformation of Maxwell's equations. Earlier chapters in this part summarize some elementary results in electricity and include a discussion of the definitions of electric and magnetic forces in polarized media. The treatment here differs in several important respects from that usually found in treatises on electricity and appears to be unnecessarily involved. It leads to the curious, though correct, conclusion that the polarization vector, as defined in this book, should vanish for a conductor under the influence of an electrostatic field.

It would have been more logical and instructive to have deduced the first-order effects of charges in uniform rectilinear motion from the relativistic formula derived in the chapter on relativistic electrodynamics instead of devoting a separate chapter to the subject. Again, in his account of the advent of the theory of relativity, Prof Cullwick specially singles out Poincaré's work, and in this respect appears to follow the lead given by the late Sir Edmund Whittaker in his "History of the Theories of the Aether and Electricity". Prof. Cullwick also dissents from the generally accepted explanation of the so-called 'clock paradox' in relativity and allies himself with Prof. H. Dingle in this controversy.

The second part of the book is on electromagnetic induction. Here the author appears to have been more successful, and the reader will find much that is useful. The distinction between electromotive force and potential difference is well drawn and illustrated by interesting examples. Likewise, the essential difference between the problem of a non-magnetic conductor rotating in an external magnetic field and the problem of a magnet rotating about its axis is made clear and is instructive. Prof. Cullwick has also rightly included in this part brief accounts of Bullard's theory of the maintenance of the geomagnetic field by dynamo action, and of magnetohydrodynamic waves. A fuller account of this new science, especially the parts which are essentially theorems in electrodynamics, would have enhanced the value of the book.

The third part of the book relates to the relativistic theory of second-order electromotive forces in moving circuits. A simple relation is shown to exist between the measurement of induced electromotive forces in systems in uniform relative motion, and this relation is illustrated by well-designed examples.

The fourth part is devoted to electromagnetic energy and momentum of moving systems. After discussing the reasons for introducing the Poynting and electromagnetic momentum vectors to retain the conservation laws of energy and momentum, the author devises examples to illustrate systems in which ponderomotive forces are 'unbalanced'. The reviewer, however, found the discussion here obscure and involved.

Prof. Cullwick also appears to be under a misapprehension about the nature of the magnetic energy of a system of electric currents. On p. 260 we read that "the hypothesis is introduced that the magnetic energy of a current circuit is the same as the kinetic energy of the effective conduction electrons, by virtue of their mean velocity along the wire". The author then derives from this hypothesis a linear relation between the magnetic vector potential and the mean velocity of the charges, this relation involving an "effective mass" which is left undefined. The reviewer is unable to agree with the findings of the author, and the hypothesis appears to be rather misleading. It is used in the chapter on superconductors to derive the familiar equations due to F. and H. London. Here the application is legitimate and indeed the linear relation mentioned above was first derived in connexion with the phenomenological theory of superconductors. But the relation cannot be universally true since it would seem to carry with it the implication that all conductors are superconductors.

To sum up, there is much that is of value and of interest in this book, but for reasons given in this notice, the book cannot be recommended unreservedly.

V. C. A. FERRARO

Tables of Partitions

Initiated and Computed by Hansraj Gupta. Computed Independently by C. E. Gwyther and J. C. P. Miller. (Royal Society Mathematical Tables, Vol. 4.) Pp. xxxix+132. (Cambridge: At the University Press, 1958. Published for the Royal Society.) 63*s.* net.

THIS is undoubtedly the most comprehensive tables of partitions ever published. The principal function tabulated is $p(n,m)$, the number of partitions of the positive integer n into at most m integral parts (or into integral parts none of which exceeds m). Table 1, occupying 87 pages, gives $p(n,m)$ for $n = 1(1)200$, $m = 0(1) \min (n, 100)$ and for $n = 200(1)400$, $m = 0(1)50$. Table 2, of 32 pages, is intended for use as an auxiliary table, by means of which $p(n,m)$ can be calculated readily for values of m not given in Table 1. It gives values of $p_2(n,m)$ for $n \leqslant 1{,}000$, the maximum value of m varying from n for $n \leqslant 50$ to 0 for $500 \leqslant n \leqslant 1{,}000$. Here $p_2(n,m)$ is the number of partitions of n into parts consisting of two varieties of integers not exceeding m and one variety of each larger integer; in particular, $p_2(n,0) = p(n)$, the number of unrestricted partitions of n. A third table, of ten pages, tabulates a range of values of $p_3(n,m)$, the number of partitions of n into parts consisting of three varieties of integers not exceeding m and two varieties of each larger integer. The range is $n = 1(1)50$, $m = 0(1)n$; $n=50(1)100$, $m=0(1)19$; $n=100(1)150$, $m=0(1)6$; and $n = 150(1)200$, $m = 0$. The final tables gives $p_4(n,0) = p_3(n,n)$ for $n = 1(1)200$.

The introduction gives an interesting review of the extensive literature on these functions, and in particular of explicit formulæ for $p(n,m)$ as function of n for fixed m ($m \leqslant 12$). It concludes with a description of the method of construction of the tables, in which, in the fourth line from the foot of p. xxxiv, $p_1(n) = p_2(n,0)$ should read $p_2(n) = p_3(n,0)$.

The rather tricky problems of layout in a table of double entry involving large numbers have been ingeniously overcome, and the tables should be easy to refer to.

J. A. TODD

Set Theory

By Felix Hausdorff. Translated from the German by John R. Aumann *et al.* Pp. 352. (New York: Chelsea Publishing Company, 1957.) 6 dollars.

HAUSDORFF'S famous work, "Grundzüge der Mengenlehre" (Leipzig, 1914), needs no introduction to the pure mathematician. In the third edition the first nine chapters are an almost unchanged reprint of the second edition. A tenth chapter has been added, dealing with the Baire condition for sets and for functions, the restricted Baire condition, and with half-schlicht mappings. This is a valuable and interesting addition.

R. G. COOKE

Linear Programming and Economic Analysis

By Prof. Robert Dorfman, Prof. A. Samuelson and Prof. Robert M. Solow. (The Rand Series.) Pp. ix+527. (London: McGraw-Hill Publishing Company, 1958.) 77*s.* 6*d.*

THIS book is one of the series presenting the results of research by the Rand Corporation. It is intended for economists who wish to learn something of recent developments in the application of mathematics to economics. The first few chapters present the method of linear programming, with some applications worked out in detail, and the special methods available for transportation problems. There is a chapter on non-linear programming and two chapters on input–output analysis as developed by Leontief. Other chapters deal with dynamic aspects of linear models and with programmes for capital accumulation. An essential idea here is optimization over time. Linear programming is discussed in relation to the theory of general equilibrium and to welfare economics. Finally, there are chapters on the theory of games and its relation to linear programming. These last chapters are added for the sake of completeness, and this is the only justification, for, as the authors point out, ". . . the 13 years that have elapsed since the publication of the "Theory of Games" (by von Neumann and Morgenstern) have seen no important applications of game theory to concrete economic problems".

The reader should find the book easy going, for the exposition is nowhere concentrated and the impression is that the authors have been allowed as many pages as they desired. This allows detailed explanation and the inclusion of many fully worked examples. But it also makes the book expensive and it means that the reader will have to spend a long time absorbing relatively little. The reviewer feels that the rate of communication between the authors and the reader will be too slow to be very satisfying. It might have been better to have said as much in fewer words.

L. S. GODDARD

Salmonellosis in Animals

By Dr. A. Buxton. (Review Series No. 5 of the Commonwealth Bureau of Animal Health.) Pp. vii+209. (Farnham Royal: Commonwealth Agricultural Bureaux, 1957.) 25*s.*

THIS book is a review of salmonellosis in animals, and, in particular, of the vast literature which has accumulated from 1888 to the present day on the many aspects of this subject. The author has been careful to include information from field studies and the natural history of disease as well as from the laboratory and the experimental work; he has interpreted these in relation to the naturally occurring disease.

A chapter is devoted to technical methods of classification of the Salmonella group of organisms, of which more than 500 have been described. Reference is made to certain details of antigenic structure, their possible relationship to virulence, and the effect which certain minor variations in the structure of the organisms have had on the detection of infection in the field.

The distribution of Salmonella serotypes among the various animals, birds, reptiles, insects, and ticks, summarizes our present knowledge. The epidemiology is well covered; obviously the author has been personally concerned with this aspect. Careful consideration is given to general aspects such as the state of the host, its diet and environment and the influence such factors exert on clinical infection.

Many problems remain unsolved in the animal disease; as yet there is no final proof of the value of vaccines or of antibacterial substances. The author is to be congratulated on bringing into one book so much information, previously available only in scientific journals; also for including data on wild and unusual animals so often neglected in the text-books.

JOAN TAYLOR

NUCLEAR POWER AND THE ENGINEER*

By Sir CHRISTOPHER HINTON, K.B.E., F.R.S.

ALTHOUGH in a narrow sense nuclear power has only introduced an alternative fuel, much more than this has been done since 1946 when the Atomic Energy Organization of the United Kingdom was first formed within the Ministry of Supply: a whole new and complicated industry has been created. The first factory, which was built at Springfields, was for the extraction of uranium from its ore and the subsequent purification of the uranium salts and their conversion into metallic uranium, which was enclosed in cans for insertion into the reactors. After irradiation in the atomic piles, these fuel elements contained plutonium, which was needed for defence purposes, and a reduced quantity of uranium-235. They were treated in chemical plants, in which the plutonium was extracted in an impure form and afterwards purified and converted into ingots of metal. The solution containing fission products was concentrated by evaporation and put into storage, while the uranium, with its depleted content of uranium-235, was purified. Before it could be re-used in reactors this depleted uranium had to be re-enriched in its fissionable isotope, and this was done in the diffusion plant which was built at Capenhurst.

In the ten years between 1946 and 1956 the problems of these ancillary plants were inconceivably greater than the problems involved in the design and construction of nuclear reactors, and of all the difficulties which we met during those years I believe that those connected with the design and construction of the chemical separation plants were by far the greatest. But these plants are likely always to remain behind the scenes; it seems probable that they will continue to be operated by the Atomic Energy Authority, and as each plant is able to process the materials required for, and produced by, several reactors, the number of these plants is likely to be limited. It is in the development and use of the reactors themselves that public interest has been mainly concentrated, and it is in this field that the greatest development is likely to take place in the future.

One of the reasons why the reactor problems presented the least of all our difficulties in those early days was that in designing them we were able to proceed in a stepwise way towards the evolution of advanced systems, whereas in the development of the ancillary processing plants we were bound to jump directly from laboratory-scale work to the design and construction of full-scale units planned to meet the requirement for many years ahead. When, in 1946, we started to design the graphite-moderated, air-cooled experimental reactor at Harwell, we had the benefit of the experience which had been gained through participation in the design of the Chalk River experimental pile, and the fact that even to-day this is probably the best general-purpose research reactor in the world is a tribute to the skill and ingenuity of Newall and Ginns, who were mainly responsible for its engineering. It consists simply of a mass of graphite moderator built up from accurately machined blocks in which rods of uranium enclosed in aluminium cans lie in a suitably spaced lattice. The heat of fission is removed by blowing air over the uranium rods and the heated air is passed through filters and discharged to atmosphere. The reacting core is enclosed within a concrete biological shield and control is exerted by moving rods of boron steel (which is an effective absorber of excess neutrons) into the reacting core through one of the biological shield walls.

The experience which was gained in designing and building BEPO was extremely valuable. At first it is worrying to feel that one is designing a complex and expensive plant where, if breakdown occurs, it is impossible to get access for repairs. This feeling led to a standard of accuracy in the construction of BEPO which was not justified. Indeed, the most important experience which we gained in carrying out this project was the knowledge of how far it was possible to depart from the theoretical requirement stated by the scientist while still meeting his practical requirement. This is the basis of all engineering art.

Our next commitment was to build the large reactors required for plutonium production for defence purposes. It was at first intended that these should be of a design similar to those at Hanford in the United States, that is, thermal reactors, graphite-moderated and water-cooled. But at that time it was not possible to build reactors of this type which had inherent stability. During operation they might become super-critical and disperse radioactive fission products over a fairly large area of the countryside. Because of this, the Americans had located their reactors in a remote situation, and had adopted safety distances from towns of various sizes. There was no evidence at the time to suggest that these safety distances could be relaxed, which made it difficult to select convenient sites in a densely populated country like Great Britain.

We know that during the War the Americans had wished to build a large gas-cooled reactor but were discouraged by the difficulty of obtaining the huge blowers that were required. The attractions of gas-cooling were, however, so great that we started an intensive study of the problem. We came to the conclusion that by putting fins on the cans of the fuel element and by compressing the coolant gas we could design gas-cooled graphite-moderated reactors which would not only produce plutonium but would also at the same time generate electrical power. Power could not be generated, however, unless the temperature of the gas leaving the reactor was reasonably high, and the problems of achieving these temperatures involved more research than we had time for. We realized that by temporarily sacrificing our objective of generating electrical power and by using air at atmospheric pressure as our coolant we should be able to build a reactor for the production of plutonium which would be inherently safe and which would not need to be built in a remote locality. This led to the construction of the Windscale reactors, which are, in fact, scaled-up versions of the large Harwell experimental reactor which we had already built.

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* Based on a discourse delivered to the British Association on August 29.

The scale of the construction can be judged by the fact that the chimneys are more than 400 ft. high and the total weight on the foundations was about 58,000 tons. But, apart from their scale, they represented only a reasonable step forward from the practice which had been evolved in designing the Harwell experimental reactor. The most important development as compared with Harwell was in the introduction of burst slug detector gear. It was only at a comparatively late stage in the design that the need for this gear was established and the technique for detection was evolved. This technique involves taking samples of the exit air from all of the channels in the reactor so that, if a defect develops in any of the fuel elements, the fission products which escape can be deposited electrostatically on a wire, which is then monitored by a Geiger counter. It was impossible to sample the exit air from all channels without introducing moving parts to the reactor. The guiding principle in all our design philosophy had been to avoid any moving parts within the active zone, and the decision to use this air-sampling gear was a difficult one, but in spite of it the essential simplicity of the design remains.

Meanwhile, we continued to work on the problem of developing a gas-cooled reactor for the production of useful power. By 1953 we had arrived at a practical scheme. In that year there was an additional demand for plutonium for defence purposes and we decided that this requirement should be met by building graphite-moderated gas-cooled reactors which would produce electrical power as a by-product, and this was done on the Calder Hall site.

In the Calder Hall reactors the heat of fission is removed from the fuel elements by cooling them in pressurized carbon dioxide gas instead of with atmospheric air as in the Windscale reactors. The uranium fuel elements are arranged vertically in the mass of the graphite moderator and the whole of the reactor core is enclosed in a steel pressure vessel which is more than 40 ft. in diameter. Hot gas leaving this vessel is passed through ducts to the heat exchangers, in which it gives up its heat to water and so generates steam, which is used in conventional turbo-generators to make electric power. The carbon dioxide gas cooled in this way passes through other ducts to the blowers, which force it back once more into the reacting core.

When the construction of the first Calder Hall reactor was only in its early stages we felt certain that it could form the basis of the programme for the large-scale development of industrial nuclear power, and this scheme was published in the White Paper of 1955.

Up to that time all British nuclear power plants had been designed, built and operated by the Atomic Energy Authority, although all the component parts had been manufactured by industrial firms. It was decided that this was the appropriate stage at which industry ought to be brought in and trained in reactor design so that the Atomic Energy Authority could proceed with its main task of developing more advanced types, while the industrial firms built the reactors which would be used by the electricity supply authorities. Four of these industrial power stations are now being built.

The electrical output of these industrial reactors will be far greater than that of the Calder Hall reactors. In the Bradwell reactor the pressure vessel which contains the reacting core has been made spherical and is of considerably greater diameter; a larger core is thereby made possible and heat transfer is improved by using a higher pressure in the circulating carbon dioxide. But essentially, the principles of design of this reactor and of the other reactors which are being built for industrial use are identical with those which were evolved for Calder Hall and which have now been in satisfactory and uneventfu operation for two years.

When I gave the Clayton Lecture to the Institution of Mechanical Engineers in February 1954, I said: "In looking at the Windscale piles you will be struck by their essential simplicity. This is, indeed, the key to pile design. The problems as initially presented to the designers rarely looked simple, sometimes they looked almost frightening in their difficulty and more often they were frightening in their high content of the unknown. The main skill in pile design has been in reducing such problems to terms in which they could be interpreted into engineering structures so simple, so well understood, that even the unknown ceased to give cause for alarm". This is true to-day of all good reactor design; in looking at the designs of Calder Hall and of the industrial reactors the most striking feature is once more their simplicity, and simplicity in reactor design must always be achieved. Simplicity is the essential of all good design.

Having looked at the course of reactor design since it started in 1946, let us try to predict its future. We have seen that in our earliest reactors, though we released large quantities of heat, we were not able to use this heat for the generation of a useful electrical power because we could not recover it at a sufficiently high temperature. By the time that the design of Calder Hall was put in hand, developments in research had made it possible to achieve temperatures which enabled us to generate useful power, but these temperatures are still low by comparison with conventional power plant practice.

If we look at the history of these conventional power plants we find that their capital cost has steadily fallen with the passage of years. More than anything else this reduction in the capital cost of steam power plants has been linked with the rise in the initial temperature which it has been possible to achieve in the steam cycle. This rise in initial temperature with the passage of time is shown in Fig. 1. The limit has been imposed by different factors at different times: in the earliest days it was controlled by the pressure which could safely be sustained in cast-iron vessels; later it was limited by the performance of cylinder lubricating oils in reciprocating engines; but for the past forty years it has been controlled by the metallurgy of the materials available for superheater, steam pipe and turbine construction. This rise in the initial temperature in the steam cycle has made it possible for higher working pressures to be used, and this in turn, operating hand in hand with other developments, led to bigger boiler and turbine units, and it is this growth in unit size and rating which, more than anything else, has brought down capital costs. But besides bringing down the capital cost of conventional steam plants, the higher top temperatures which have been achieved in the steam cycle have increased the efficiencies which have been achieved. James Watt's engines consumed 6 lb. of coal per horse power hour; to-day the modern

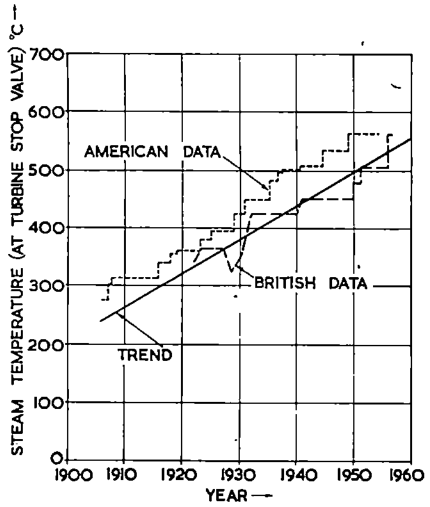

Fig. 1*a*. Rise of steam temperature with passage of time

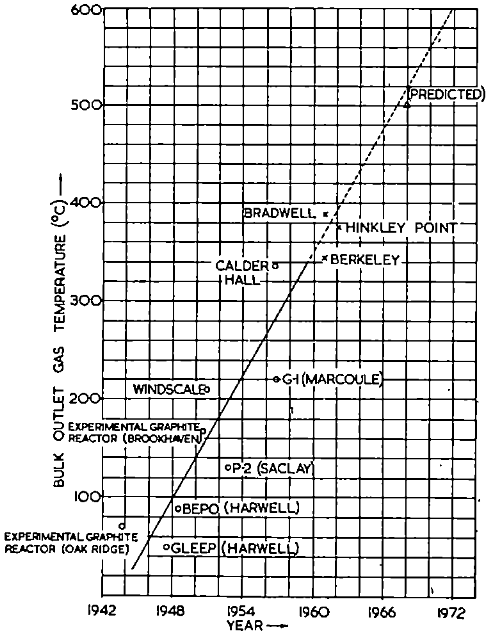

Fig. 1*b*. Rise of outlet gas temperature with passage of time

steam generating plant consumes only ¾ lb. of coal per horse power hour, and this rise in efficiency has sprung almost entirely from the rise which has been possible in the initial temperatures in the heat cycle.

When the Windscale reactors were built we were not able to recover the heat of fission at a high enough temperature to enable us to generate any useful electrical power. The considerations which held us down to these low temperatures were the possibility of reaction between the graphite moderator and the cooling air and, secondly, the possibility of trouble with the fuel elements. These fuel elements consisted of rods of uranium metal about 1 in. in diameter enclosed in aluminium cans. Aluminium was used as the canning material mainly because it has a low cross-section for neutron absorption; magnesium was considered as an alternative material but was rejected because of the possibility that the cans might catch fire and cause great damage. But while the use of aluminium had the advantage of avoiding this difficulty, it had the corresponding disadvantage that it was known that aluminium formed a metallic compound with uranium and that this chemical reaction proceeded more rapidly as the operating temperature rose; and it was mainly this consideration which held us down to the temperatures which were used in the Windscale piles.

The construction of the Calder Hall reactors, in which the heat of fission was recovered at a sufficiently high temperature to enable it to be used to generate useful electrical power, was made possible mainly by researches which overcame this difficulty. An alloy of magnesium was developed which made the possibility of the ignition of the can much more remote, and in addition, the use of carbon dioxide as a coolant instead of air still further reduced the risk of fire. Since that date the experience which has been acquired in the fabrication and use of fuel elements of the Calder Hall type has made it possible to assume in the design of the reactors for the electricity authorities that it will be possible to achieve temperatures slightly higher even than those which are used at Calder Hall. We find, then, that the short history of nuclear power shows an upward trend in the top temperature which can be achieved from our reactors in exactly the same way that we find that the much longer history of conventional power plants shows an upward trend in the top temperature of the heat cycle (Fig. 1).

Besides the top temperature which can be achieved in the cooling gas leaving the reactor, there is another major factor in reactor design which affects the capital cost per kilowatt of power produced. This is the rating of the fuel elements. If the rating of the fuel elements can be doubled (that is to say, if twice as much heat per second can be produced from each kilogram of uranium in the reactor) then obviously twice as much heat and approximately twice as much power can be produced from a reactor of given size and the capital cost per unit of heat output will thereby be reduced. There are many factors which affect the fuel element rating which can be adopted, but of these the most important is the temperature at the centre of the uranium fuel element. The heat of fission is generated throughout the whole mass of uranium and the heat released in the centre of the fuel element must be conducted to the surface for removal in the stream of cooling gas. This flow of heat demands a temperature gradient, and it therefore follows that the temperature of the centre of the uranium rod must be higher than the temperature at its surface. The higher the rating of the fuel element, the greater must be the temperature gradient across it in order to conduct heat from centre to surface. Higher fuel element ratings, therefore, mean higher centre temperatures in the uranium and, when this is accompanied by the higher surface temperatures which are necessary in order to enable us to achieve higher temperatures in the exit cooling gas, we soon find that we are operating at uranium temperatures which are likely to be troublesome. But Fig. 2 shows how fuel element ratings have risen in the past, and if reactor technology is to continue to develop in the future this trend must be continued.

We are therefore faced with the conclusion that improvement in industrial nuclear power plants can only be made possible by increasing top temperatures and the heat ratings of our fuel elements and that this demands fundamental development in fuel element design. These developments involve research

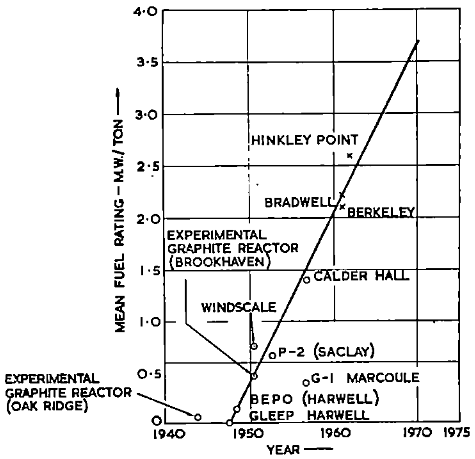

Fig. 2. Rise in fuel rating with passage of time

which is largely of a metallurgical character, and so once again in the nuclear field we find that, as has so often happened in the development of conventional power plants, the engineer must rely on the metallurgist for research and development work before he can make real progress. In my 1954 Clayton Lecture I said, "The limiting factor in reactor design is the performance of the fuel element and this is likely to be the case for many years to come".

No great improvement in the top temperatures can be expected while we continue to use magnesium alloy canning material. It will be necessary to use either stainless steel, which is an uneconomical absorber of neutrons, or some material having a low neutron cross-section and a high melting point, such as beryllium. But beryllium is an expensive metal and one which is costly and dangerous to handle. It will be necessary to minimize the quantities which are used, and this will mean higher ratings so that the maximum amount of heat is obtained from every fuel element. With high ratings it will be impossible to employ uranium rods of the diameter which are at present used, and even if the fuel elements are made with smaller dimensional cross-sections it is probable that the ratings which are adopted will be so high as to give rise to fuel element centre temperatures which would be dangerous with metallic uranium. It will therefore be necessary to use either a ceramic or a cermet fuel element, and this will additionally be necessary because the steps that will have to be adopted in order to achieve the requisite top temperatures and heat ratings will make the fuel elements far more expensive, and we will require a far higher burn-up of the fissile material than can be achieved with metallic uranium in order to bring their cost per unit of electricity generated down to a reasonable level.

These developments involve an immense amount of difficult research and development work, but it is essential that this work should be carried out expeditiously and successfully. The cost of electricity generated in the nuclear power plants which are under construction is estimated to be between 0·66*d.* and 0·7*d.* per unit. Based on current prices, power will be produced from the best conventional plants which are being built to-day at a cost of only 0·54*d.* per unit, and it is therefore obvious that the present nuclear power plants can only be justified as the foundation for improving nuclear technology. But in calculating the nuclear power cost of 0·66*d.* to 0·7*d.* per unit it has been assumed that these nuclear power plants will be used for base load only and will not be asked to take any share of the peak load. In a conventional power plant only about one-third of the cost of each unit of electricity generated arises from capital charges, the other two-thirds arising from fuel and operational charges. In the nuclear power plants which are at present being built, this proportion is approximately reversed and two-thirds of the cost of each unit of electricity generated arises from capital charges, while only about one-third arises from fuel costs and operating charges. It is therefore obvious that if the present nuclear power plants are asked to take a share of peak load and therefore to work at a lower load factor, they will be placed at a great disadvantage as compared with conventional plants. This was not a matter of great concern at the time when the first plan for nuclear power was issued as a White Paper in 1955. That plan envisaged that by 1965 about 1,800 megawatts of nuclear power plant capacity would be installed. At such a rate of expansion it would be possible to use nuclear power plants on base load for a considerable time. But for various reasons the plan was expanded in 1957 and now envisages an installed nuclear capacity of about 5,000–6,000 megawatts by 1966. At this rate of expansion, nuclear power plants will have to carry a share of peak load by 1971 or 1972. This means that the nuclear power plants which are inquired for in 1966 and ordered in 1967 must have capital costs which are so much reduced as to enable them to compete with conventional power plants when taking a share of the peak load.

Each nuclear power plant which has hitherto been ordered has shown improvement in capital costs as compared with the previous plant, but virtually all this improvement has arisen from straightforward engineering development of the Calder Hall design and scarcely at all from basic scientific or metallurgical improvement. The field for these straightforward engineering developments must be a limited one. Beyond a certain point, it will be impossible to progress unless fuel element technology has been developed to a point which will enable higher top temperatures, higher fuel element ratings and higher fuel element burn-ups to be achieved, and to meet the requirement of the expanded programme this must be done by 1966. In the Axel Johnson Lecture which I gave before the Royal Swedish Academy of Engineering Sciences in 1957 I suggested that if the rate of progress which has been achieved in the nuclear field in the past can be continued, and if the cost of coal continues to rise as it has done, nuclear power should begin to be cheaper than conventional power in the reactors which are commissioned in 1963. But this prediction was based on the rate of expansion of nuclear capacity which was envisaged in the initial White Paper and does not assume the greater fall in load factor which is involved in the expanded programme of 1957. Moreover, there has, I think, been a tendency to assume that these forecasts were predictions of what would happen rather than indications of what should happen. The work described in that paper was done to determine what was a reasonable target for the research and development departments and for the engineers. The results predicted can only be achieved if development continues with the same energy, skill and success in the future as in the past.

It is of vital importance that this rate of progress should be achieved. The engineering technology of the construction of nuclear power plants differs in many important respects from that of the construction of conventional plants, and the engineering capacity of manufacturers in the power plant field is being swung into the manufacture of nuclear plants to an important degree. If, by the 1960's, nuclear plants are not developed with capital costs so low as to enable them to compete with conventional plants when carrying a share of peak loads, then we shall be faced with the alternatives of continuing to build nuclear power plants which will produce more expensive electricity than the conventional power plants that could then be designed, or of swinging the manufacturing technology back from the nuclear to the conventional field.

The expanded nuclear programme of 1957 was adopted for reasons which were considered to be good. It will, however, be a mistake not to realize that, besides involving a far greater rate of capital investment, this larger programme demands a higher rate of scientific and technological development. Progress is necessary not merely in the field of the gas-cooled reactor but also in the development of the fast reactor which, so far as one can see at the moment, is the only device which will enable us successfully to use up the by-product plutonium which is produced in reactors of the Calder Hall type. Moreover, the advance must be made with that same regard to safety in the future which has been achieved in the past; public opinion is so sensitive to nuclear risks that even a minor accident might lead to a setback in the programme which would involve immense difficulties. The problems and the challenge of the next ten years are as great as those of the first ten years. The industrial use of nuclear power cleared its first hurdle in 1956 when Calder Hall went into operation; it must clear its second hurdle with equal success in 1966 when we must be able to build reactors the design of which is so advanced, and the capital cost of which is so low, that they are able to take their share in carrying peak loads of electricity.

CONTROLLED NUCLEAR FUSION REACTIONS

THE presentation of full and authoritative accounts of research on controlled nuclear fusion reactions was a major feature of the second Geneva Conference on the Peaceful Uses of Atomic Energy. This was so partly because of the potential economic importance of the subject, and partly because the conference provided the first opportunity for scientists of all countries to discuss freely their progress to date and their hopes for the future. Many of the principal speakers emphasized that this belated demise of security restrictions is itself a major step forward. Both Britain and the United States formally announced total declassification of all research in this field, and presented data on every aspect of their research programmes.

Approximately one hundred papers were presented, distributed among countries as follows: United States, 66; U.S.S.R., 16; United Kingdom, 9; France, 5; Sweden, 4; and one or two from each of a number of European countries and Japan. While the papers varied considerably in length and significance, these numbers probably reflect at least qualitatively the national research efforts, except perhaps for West Germany, where the work of three research centres was covered by only one paper.

Nearly half the papers were presented orally. The information contained in them was supplemented by an informal session on co-operative processes in plasmas, by films illustrating work in the U.S.S.R. and the United States, by the publication of four volumes[1] of papers from the Russian Academy of Sciences describing work since the inception of fusion research in the Soviet Union, by an authoritative survey of the American programme written by A. S. Bishop[2], and by equipment and data on show at the exhibition. The exhibition displayed the principles of and practical experimentation in fusion research on a scale which, thanks to the American section, must surely be unprecedented for a conference on any scientific subject. Fourteen working experimental set-ups were exhibited, fully instrumented and staffed by research workers. The principles involved, particularly unfamiliar ones such as the rotational transform used in the 'Stellarator', were admirably explained with subsidiary equipment, and a wealth of detail was exposed in static exhibits. Delegates lacked neither stimuli for discussion nor food for thought.

The possibility of producing controlled power from the deuterium – tritium and deuterium – deuterium fusion reactions exists because envisaged conditions in a thermonuclear reactor are calculated to produce more nuclear energy than that used in heating and containing the hot gas. No doubt was cast on this principle in the case of deuterium – tritium reactions. But the energy balance for the deuterium – deuterium reaction is much more marginal, and papers dealing with this problem provided no encouragement that it will be achieved more easily than earlier calculations suggested. A relativistic calculation of the power radiated in harmonics of the electron cyclotron frequency suggested an energy loss hitherto ignored which could in some circumstances be serious. All detailed schemes presented envisaged working only with deuterium – tritium reactions, and on present ideas will require an adequate economic supply of lithium-6.

The problem of generating thermonuclear energy can be tackled in the first instance by using sufficiently rapid compression and high density of deuterium to avoid serious inefficiency from lack of thermal insulation. Academician Artsimovitch reported that experiments showed that deuterium – deuterium reactions, presumed to be thermonuclear, can be produced by heating and compressing deuterium with conventional explosives. Dr. E. Teller canvassed the possibility of underground nuclear explosions, which he suggested could be used for what he aptly called geographical engineering, and to produce a source of geothermal power. In papers dealing with straight unstabilized pinched discharge, it was reported that the energies needed to produce a net output of energy before the magnetic confinement is destroyed by instabilities are calculated to correspond to the explosion of at least ten tons of high explosive. Moreover, experiments suggest that the power used in a straight pinched discharge is limited by evaporation of wall material.

To obtain a more manageable release of energy, much longer time scales are needed; and the majority of papers dealt with the problem of confining hot plasmas with electromagnetic fields, for times long compared to the decay-time of inertial effects and to the growth-time of instabilities. The great majority of these papers were devoted to three principal configurations of magnetic field: the toroidal pinched discharge in which the confining field is primarily the self-magnetic field of the discharge; the Stellarator configuration, where the confining field is generated by external solenoidal windings on a torus or some other form of closed tube; the 'Magnetic Mirror' configuration, where the configuration is that produced in an ordinary straight solenoid, with the field strongly enhanced at the ends of the solenoid to form reflecting zones for the great majority of particles.

Experimental results on the toroidal pinched discharge were reported by groups working at Los Alamos, Livermore, Harwell, Associated Electrical Industries (Aldermaston), Moscow, Saclay and Upsala. Informal discussion suggested that the large apparatus 'ALPHA', built this year at Leningrad, had only just come into operation, and no results from it were presented. The discharge currents reported ranged up to three or four hundred kiloamperes, with rise-times varying from about 10 μsec. in small apparatus to 1·2 msec. in the 1-metre bore ZETA. Results obtained by various groups agreed well on the main points, which are: the pinch effect constricts the current channel away from the wall of the tube; the use of a longitudinal stabilizing field produces a measure of gross stability, but the plasma is not wholly quiescent; the electron temperatures are not more than about $0\cdot5 \times 10^6$ ° K., in spite of the large power input (100 megawatts in ZETA, 900 megawatts in 'Perhapsatron *S*-4') and the high ion energies ($1–5 \times 10^6$ ° K.) measured in ZETA and SCEPTRE; deuterium-deuterium reactions are produced in the plasma, but the energy distribution of the neutrons is anisotropic.

A number of authors dwelt on the cause of the low electron temperature. This is clearly due to a loss of energy from the plasma to the tube walls, but none of a variety of possible energy loss mechanisms has yet been clearly identified. Dr. S. A. Colgate, of Livermore, reported a substantial loss of energy due to electrons of about 5 kV. energy striking the walls; he also reported evidence which demonstrated the importance of gas which continually leaves the walls during the discharge. Straight-tube discharge experiments reported from Los Alamos demonstrated the onset of small-scale instabilities after an initial period of stability. Theoretical papers showed that in the hydromagnetic approximation complete stability could not be predicted for any of the magnetic field configurations so far observed in these pinched discharges. In addition, a number of authors proposed that run-away electrons could generate violent plasma oscillations which could destroy containment. There is also a possibility of the plasma pressure in the discharge becoming too high for containment.

The work on the 'Stellarator' configuration, carried out largely by Prof. L. Spitzer's group at Princeton, has shown that gross containment of a plasma is possible by this means, using a variety of configurations to produce the rotational transform. The containment is limited by a variety of difficulties, the first being contaminants which get into the plasma from the walls. To overcome this, a very high standard of vacuum techniques has been developed, including baked-out stainless steel assemblies, and the 'Divertor', which is a special configuration of magnetic fields which diverts impurities emitted from the walls into cold traps. Secondly, the simplest 'Stellarator' configuration is hydromagnetically unstable, and additional stabilizing windings have been used. Thirdly, ohmic heating by toroidal currents is accompanied by runaway electrons which, as in the pinched discharge, may create violent plasma oscillations which lead to loss of containment. Relevant to this last difficulty, successful experiments on power absorption at the ion cyclotron frequency and other resonances were reported, which show great promise of providing an alternative heating mechanism free from difficulties connected with run-away electrons. Experiments on resonance absorption, in a simple discharge system, were also reported by a group of workers from Kharkov.

Extensive observations of ohmic heating in 'Stellarators' were reported which indicate electron and ion temperatures of about $0\cdot5 \times 10^5$ ° K.; however, because of the above difficulties, the plasma is not yet well confined and reaches the wall in about 10^{-4} sec. Theoretical papers from Princeton dealt fully with the principles of the configuration, the problem of stability and the heating of the plasma by oscillating electromagnetic fields. 'Stellarator' work reported from the U.S.S.R. dealt mainly with unpinched discharges in high magnetic fields; results on stability and temperature were very similar to those reported from Princeton.

Work on the 'Magnetic Mirror' configuration was reported by several American groups and, briefly, by Russian workers from Moscow. The most detailed work on the confining properties was reported in a series of papers from Livermore. Using relatively slowly rising magnetic fields (adiabatic approximation), extensive results have been obtained which demonstrate the confinement, compression and heating of initially injected plasma. The leakage of particles out of the mirrors has been studied in detail, and found to be in rough accord with that expected on binary collision theory. A striking result of this work is that no gross instabilities have yet been encountered; consequently, Dr. R. F. Post and his colleagues have been able to demonstrate a control of the plasma unmatched in other systems. Microwave measurements and the flux and energies of particles escaping through the mirrors indicate densities of up to 10^{14} cm.$^{-3}$, containment times of about 10^{-3} sec., and electron and ion energies of about 10 keV. and 1 keV. respectively. These workers are careful to point out that they have not achieved a sufficiently high ratio of gas pressure to magnetic pressure in sufficiently general circumstances to conclude that large volumes of plasma at useful temperatures and pressures could be stably confined in 'Magnetic Mirror' configurations. Moreover, there is some radial diffusion to the walls which exceeds that calculated for binary collisions.

Due to the leaky nature of the 'mirrors', particularly at low temperatures, the injection of particles or plasma into a 'mirror' machine presents a major problem. Papers from the Oak Ridge group reported considerable progress on injection of D_2^+ ions at high energies. These molecular ions are dissociated in an intense carbon arc inside the mirrors, leading to trapping of deuterons. The ion beams are not yet sufficiently intense to counteract losses due to charge exchange and scattering from neutral atoms and impurities within the mirrors. With sufficiently intense beams, a 'burn-out' of the neutral and impurity atoms should occur. The Russian workers in Moscow propose, in their large OGRA machine, to provide a sufficiently long path for the D_2^+ ions to be dissociated without the use of a carbon arc. Experimental work at the U.S. Naval Research Laboratory demonstrated that rapidly applied mirror fields can provide sufficiently rapid shock heating of a cold plasma to produce considerable trapping and compression to high densities and temperatures. A Los Alamos group reported detailed studies of the neutron emission from such fast-rising mirror fields. Yet another method of heating plasma in the 'mirror' geometry was reported by other groups working at Los Alamos and Livermore, in which radial currents are generated by a central axial electrode. Such currents also produce a rotation of the plasma, as in a Faraday disk. Experimental observation on rotating plasmas were also reported in papers from the University of California Radiation Laboratory at Berkeley.

None of these three principal configurations is obviously hydromagnetically stable, at least in the simplest version; and reports of the experimental observations were complemented by a formidable array of theoretical papers dealing with stability problems. Unfortunately, calculations are straightforward only in the simple hydromagnetic approximation; but the stability may, in fact, depend crucially on such factors as finite Larmor radius, viscosity, anisotropic pressure, toroidal geometry, and other factors which are extremely difficult to include in the already complicated hydromagnetic equations. Other theoretical papers dealt with the run-away electron problem, and the excitation of plasma oscillations by such run-aways.

None of the other confinement schemes reported has been investigated experimentally in detail, and most are in the speculative stage. A machine called the ASTRON, now under construction at Livermore, was discussed by Dr. N. Christofilos; it incorporates a unique feature in that the magnetic configuration is provided both by external coils, and also by a sheath of injected relativistic electrons circulating in the plasma.

A number of papers discussed in detail the practical problems of plasma diagnostics, and while much good work was reported, it was clear that there is still substantial scope for progress in this aspect. A useful contribution was made by a British paper surveying the role of materials in controlled thermonuclear research, describing in particular the concept of 'unipolar' arcs as a process by which impurities are released from the walls.

Thus, the material presented at the Conference showed that in spite of intensive research in a number of countries, there are still many unsolved problems. The three configurations chiefly discussed all have their peculiar difficulties, and neither experimental nor theoretical work is sufficiently far advanced to decide whether these difficulties can be overcome. In no device has there been an unequivocable demonstration of a controlled thermonuclear reaction regardless of energy balance considerations, although according to Academician Artsimovitch "the question of whether a given neutron belongs to the noble race of descendants of thermonuclear reactions or whether it is the dubious offspring of the shady acceleration process, is something that may worry pressmen; but it should not, at the present stage in the development of our problem, ruffle the composure of the specialists".

The emphasis at the Conference was on basic research in plasma physics, and after the Conference most delegates appeared to agree that this will be the most fruitful type of research which can be done in this field for a number of years. R. S. PEASE

[1] "Plasma Physics and the Problems of Controlled Thermonuclear Reactions", edit. by Leontovitch (U.S.S.R. Academy of Sciences, 1958).

[2] Bishop, A. S., "Project Sherwood, The U.S. Programme in Controlled Fusion" (Addison-Wesley, 1958).

AIR SHOWERS OF SIZE GREATER THAN 10^5 PARTICLES*

(3) COMPARISON BETWEEN THE RESPONSE OF GEIGER COUNTERS AND SCINTILLATION COUNTERS

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EXPERIMENTAL investigations of the extensive air showers of cosmic rays have been made by several groups in which scintillation counters or Geiger counters are used for determining the local density of shower particles at several points in a horizontal plane. From these data the shower size and position of the core of the shower may be determined on the basis of an assumed, or experimentally determined, shower structure function, which relates the particle density to the distance from the core. A Geiger counter records only the traversal of one or more ionizing particles through it, while the scintillation counter provides a pulse-height which is proportional to the total ionization produced by all the particles traversing it. The number of particles is then generally taken as the total pulse-height divided by some average pulse-height obtained from the traversal of the scintillator by single cosmic-ray μ-mesons. The estimates of particle density obtained from different types of detector may therefore differ. The present observations were made with the Sydney air shower array in order to compare the response of a tray of Geiger counters with that of the scintillation counters of which the array is comprised.

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* The first article in this series was published in *Nature* of October 4, p. 905, and the second in *Nature* of October 11, p. 973.

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The array of scintillation counters and the method whereby the size of shower and location of core are obtained for each shower has been described[1]. Also included in the array was a tray of forty Geiger counters of total area 0·382 m.^{2} (see Fig. 1, ref. 1). For each shower detected by the array the number of Geiger counters struck was also recorded on the same punched paper tape which carried the scintillation counter pulse-heights. The number of Geiger counters struck in each shower was then correlated with the density of scintillator particles at the location of the Geiger tray. This density was predicted by the electronic computer SILLIAC, from the computed size of the shower and the location of the shower core. The density of particles predicted at a point occupied by a scintillator has already been compared with the observed scintillator particle density[1] and shows good agreement between prediction and observation.

The predicted density of scintillator particles has been compared with the density of particles as it would be measured by Geiger counters by assuming that $\rho_g = \beta\rho_s$, where ρ_g is the Geiger particle density and ρ_s is the predicted scintillator particle density. It remains to find the best value of β to fit the observations.

The probability that out of forty Geiger counters, each of area a, exactly n Geiger counters will be struck by an incident density of ρ_g particles is assumed to be binomial and is then given by:

$$P(n) = \frac{40\,!}{n\,!\,(40-n)\,!}\{1 - \exp(-\beta\rho_s a)\}^n \times \{\exp(-\beta\rho_s a)\}^{40-n}$$

The total number of showers recorded with the Geiger tray in use was 1,009. For each shower, ρ_s was computed from the location of the core and shower size, and the expression:

$$-n \log_e \{1 - \exp(-\beta\rho_s a)\} + (40 - n)\beta\rho_s a$$

computed for each of forty values of β, ranging, in steps of 0·03, from 0·1 to 1·27.

For each value of β, a total was formed by summing these expressions for all showers. These forty totals then represent the β-dependent parts of minus the logarithm of the probability that the results observed could have been caused by the corresponding value of β. We therefore take that value of β having the lowest total to be the best estimate of the Geiger to scintillator ratio. This value is 0·67. The relative likelihood of the next lowest value tried, 0·64, was exp (− 12), and that of the next highest value, 0·70, was exp (− 2). The value 0·73 had a relative probability of exp (− 21). It therefore seems reasonable to ascribe to β the value 0·68 ± 0·02.

This value has been used in order to transform the shower sizes determined by the analysis of our scintillator observations into the equivalent sizes which would be obtained by using an array of Geiger counters. Because of the form of the shower structure function, this consists of multiplication of our computed number of particles in the shower by the factor 0·68.

While the result of this analysis gives us a method of comparing the estimates of shower sizes obtained by different types of detectors, it is quite possible that the ratio of Geiger particle density to scintillator particle density may vary with distance from the shower core, in which case the shower structure function as measured by a scintillator array would differ from that measured by a Geiger array, and the use of the value of β obtained by the method described above to convert shower sizes into 'Geiger particle' sizes would no longer be strictly valid.

If β is a function of the radial distance r, then the value of β we have obtained is a weighted mean value, the weights being proportional to the frequency of occurrence of showers at a particular distance and to the density of particles $\rho(r)$ at this distance. A correct size conversion factor should have the form:

$$\frac{N_g}{N_s} = \frac{\int r\beta(r)\rho_s(r)\mathrm{d}r}{\int r\rho_s(r)\mathrm{d}r}$$

The data are at present being analysed for evidence of a variation of β with distance from the shower core. The present indications are that such variation as may exist will have an insignificant effect upon the shower size spectrum already quoted[1].

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[1] Brennan, M. H., Millar, D. D., and Wallace, C. S., *Nature*, 182, 905 (1958).

FURTHER OBSERVATIONS ON TUMOUR-ENHANCING FACTORS: THEIR BEARING ON THE IMMUNOLOGICAL THEORY OF CANCER

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WE[1] have described the enhancement of transplanted homologous tumour growth by pretreatment with tumour saline-soluble protein, a lipoprotein fraction, a refined pure phospholipid fraction or crude phospholipid derived from frozen tumour. Since that time the work has extended and the now voluminous details have been incorporated in a thesis by one of us (R. W.). The consistency of the results is a striking feature of this work. The tumours mainly used were the Sheffield *Rd*/3 sarcoma, the Walker carcinoma of the rat and the Crocker sarcoma of the mouse.

Frozen tumour (0° C. for 14 days) yields more active extracts than fresh. Crude phospholipid is only active when derived from frozen tissue. The crude substance from fresh tumour becomes highly enhancing after final precipitation of the tumour-enhancing factor with acetone and magnesium ions, but the saline-soluble fraction is active when prepared from fresh homogenized tissue.

The following facts are all relevant to the possible mode of action of enhancing factor.

The enhanced tumour retains its property indefinitely in the same strain of animal. It is a permanent inheritable property.

Enhancement by enhancing factor from a similar tumour is maximal or nearly so; further enhancement by a second treatment is not obtained. Enhanced tumour contains more enhancing factor than unenhanced. When a tumour after long transplantation has achieved its maximal growth-rate, enhancing factor is devoid of effect. This accounts for failure to obtain enhancement in Sheffield in the *Rd*/3 sarcoma which has been propagated in the same strain for many years and for success with a recently induced slower-growing sarcoma.

Enhancement is thus a form of induced rapid 'adaptation' to the immune resistance caused by strain differences in the host. A tumour springing from an inbred strain does not respond to enhancing factor treatment in this strain.

The enhanced tumour has the remarkable capacity of inducing a similar permanent property in a normal tumour inoculated in the same animal. When such tumours are transplanted separately in opposite flanks the normal grows out at the enhanced rate. A typical experiment is shown in Table 1. It is not even essential that the enhanced tumour be still present, for if grown in the tail to a moderate size, followed by removal of the tail, a normal tumour afterwards transplanted grows at the fully enhanced rate. This again is a permanent reproducible property.

Table 1. GROWTH OF BILATERALLY TRANSPLANTED ENHANCED AND NORMAL *Rd*/3 SARCOMA AND OF A TUMOUR MIXTURE IN RATS (GROUPS OF 6)

Transplant	Original tumour wt./100 gm. carcass (12 days)	Re-transplant tumour wt./100 gm. carcass (12 days)
Bilateral:		
Enhanced tumour	14·1 ± 1·6	14·6 ± 1·4
Normal tumour	13·6 ± 0·6	14·9 ± 1·5
Mixture—half and half (w/w)	4·8 ± 0·9	3·8 ± 1·6
Enhanced:		
Tumour alone	14·0 ± 1·3	12·9 ± 0·9
Normal:		
Tumour alone	5·0 ± 1·0	5·9 ± 1·0

A perhaps even more surprising effect is that when enhanced and normal tumour are mixed before inoculation the tumour grows at a normal or often subnormal rate (Table 1). This reversal is again a permanent and reproducible change. Some effect is observed when the normal forms 10 per cent only of the mixture and at the 30 per cent level the effect is maximal.

Soluble protein or phospholipid from normal tissues (for example, liver, kidney, spleen) or from another tumour type (for example, Walker) also show enhancing factor activity, but it is roughly half that of enhancing factor derived from the tumour under test. Even tumour of a different species contains enhancing factor; mouse Crocker tumour phospholipid, for example, was as active on a rat sarcoma as phospholipid from normal rat tissue. Hen egg phospholipid was, however, not enhancing, so that activity may be dependent on a fairly close species relationship. There is, however, a high degree of tissue specificity in enhancing factor, for when derived from a similar tumour it is at least twice as active as that from another tissue.

Table 2. EFFECT OF 1-2-5-6-DIBENZANTHRACENE (INTRAPERITONEALLY) AND YEAST ZYMOSAN (INTRAVENOUSLY) ON THE GROWTH OF ENHANCED AND NORMAL *Rd*/3 SARCOMA

Amount	Type of sarcoma	No. rats	Tumour wt./100 gm. carcass at 12 days
20 mgm. DBA/kgm. body wt.	Enhanced	6	17·2 ± 1·3
		2	11·9 ± 1·0
		2	2·2 ± 0·2
	Normal	1	4·2
		3	2·0 ± 0·4
		4	0·6 ± 0·3
			Regressing
		2	Complete regression
Nil	Enhanced	10	19·5 (± 3·1)
	Normal	10	9·0 (± 1·6)
4 × 20 mgm. kgm./body wt. zymosan	Enhanced	4	11·7 ± 2·1
	Normal	3	1·0 ± 1·3
	Normal	1	Complete regression
Nil	Enhanced	8	18·3 ± 1·7
	Normal	8	8·8 ± 1·0

The action of tumour inhibitors provides another clue to the nature of enhancement. The enhanced tumour is much more resistant to the carcinogen dibenzanthracene, and to repeated small doses of yeast zymosan both of which powerfully inhibit the growth of the normal tumour (see Table 2). Such treatments augment the resistance of the host to the tumour, and enhancing factor must therefore either greatly lower the general resistance or protect the tumour from its effects. Among many points in favour of the latter view the fact that enhancement continues in the untreated host is decisive.

The chemistry of enhancing factor, more particularly of the active phosphatides which are more readily obtainable in bulk than the lipo-proteins, has been intensively studied. Why is crude phospholipid from non-frozen tissue inactive and even inhibits tumours? Freezing destroys or inactivates the factor, which can be removed from crude lipid by a final treatment with acetone and magnesium ions. There is some evidence that this inhibitory factor is an unsaturated fatty acid, which is gradually inactivated (? saturated) in the frozen state.

A 'cephalin' tumour fraction containing all the amino-N-phosphatides as obtained by fractionation of refined phospholipid on a silicic acid column and a related fraction, but devoid of acetyl phosphatides, as obtained by chemical extraction, has full enhancing activity when mixed with cholesterol but none without. The choline-containing lecithin fraction, though it contains no cholesterol, acts like it in this respect. The sub-fractions of tumour 'cephalin'[2], phosphatidyl ethanolamine, phosphatidyl serine and inositol phosphatide were inactive, as was also crude acetal phosphatide[3]. The silicic acid column choline-containing fraction is not only non-enhancing with or without cholesterol but is sometimes strongly inhibitory. Pure lecithin[4] and crude sphingomyelin[5] were both inactive. With J. W. Westrop[6] it was shown that the powerful hæmagglutinating effect of tumour and normal tissue 'cephalin' can be induced by a lipid–lipid interaction of ethanolamine phosphatide and a phosphatidic acid. Agglutination is chemically closely associated with enhancing phosphatide, and it is quite possible that a similar lipid–lipid interaction is involved in enhancement.

The tumour lipo-protein fraction (50 per cent ethanol-soluble fraction of the soluble proteins) contains not only all the enhancing activity but also strong hæmolytic and, in the presence of free –SH groups, agglutinating activities. It comprises only 2–4 per cent (dry weight) of the tumour protein and contains about 10 per cent lipid and probably nucleic acid.

It appears to account for the total enhancing activity of the tumour. In terms of phosphatide it is estimated to be much more potent than tumour 'cephalin'.

There is no doubt that enhancement is an immunological process. It is a hereditable property of the cell, which can be induced systemically in a remote unenhanced tumour. Serum globulin from rats bearing an enhanced tumour has slight, but definite, enhancing power. Enhancement fails to occur when concurrent cortisone treatment is given. One argument against any pharmacological effect is that admixture of active phosphatide with a tumour inoculum results in no, or very little, enhancement. Another is that tumours indigenous to an inbred strain cannot be enhanced by treatment. The fact that enhancement is strictly strain-specific is crucial. The Crocker tumour, capable of growth in several strains of mice, when enhanced in one strain, shows no enhancement in another untreated strain unless previous enhancing factor treatment has been given. The enhanced tumour, even after growing for many generations in a non-enhanced strain, retains full enhancement in the strain in which it was enhanced. In a mouse strain (*C 57B*) normally completely resistant to the Crocker tumour, prior treatment with enhancing factor enabled it to grow readily to a lethal size. Absolute resistance to strain-specific breast tumours can be broken down and prolonged growth obtained. The fact that both active tumour phosphatides and lipo-proteins induce antibodies reacting *in vitro* with the phosphatide underlines the immunological nature of the effect.

Tissue phosphatide or lipo-protein fractions do not induce the characteristic tissue response, including a plasma cell increase in the spleen, seen when homologous living cells are injected[7]. It seems likely that pre-treatment with enhancing factor provides primary sensitizing antigen, and a rapid outflow of lipo-protein antibody is stimulated by the secondary challenge with living tumour cells. It was postulated[1] that such an antibody may be an incomplete blocking antibody, the primary antigens being modified by freezing or the extraction processes in which, as has been suggested[8], destruction of nucleoprotein antigens leaves some cytoplasmic antigens intact.

The fact that a new and permanent strain of cells appears is all-important and it would seem that either adaptation and/or selection is involved. In favour of selection is the speed of the effect, for it was found both by direct weighing and by re-transplantation that permanent enhancement occurs within 48 hours. It seems unlikely that adaptation, for example, by iso-antigenic deletion resulting in a strain identical to the host could occur in so short a time. We have some evidence that the enhanced tumour contains more enhancing factor rather than less. There is also evidence[9] that widely transplantable tumours contain more isoantigen than do more restricted tumours.

The evidence favours selection of more rapidly growing cells by a lipo-protein antibody. Why is such an effect strain-specific ? In the case of the phosphatides it is likely that after injection they form a lipo- (nucleo-?) protein complex, which behaves as an auto-antigen. When challenged with living tumour cells the host, already sensitized to tumour lipid, could rapidly produce antibody to tumour lipo-protein containing the same haptene. Since it is the 'cephalin' phosphatides that enhance, the antibody would be a 'cephalin'-protein complex specific for protein (iso-antigen) of that strain. If a different strain is inoculated with the enhanced tumour, a new iso-antigenic relationship is established and the normal immune response occurs. Enhanced cells are presumably selected because they contain more surface antigen, enabling them to attract more blocking antibody and thus prevent nuclear iso-antibody reaching its target. This must also hinder the release of nuclear iso-antigen, for the enhanced tumours elicit a weaker immune response from the host, as judged by the size and plasma cell content of the spleen, than the unenhanced. It seems feasible then that a non-lethal lipo-protein antibody blocks both the extracellular release of nuclear iso-antigen and access of nuclear iso-antibody to the nucleus. In order to account for strain specificity the responsible surface antigen must be structurally related to nuclear iso-antigen, possibly having the same protein or nucleoprotein combined with 'cephalin' phosphatide. Enhancement would on this basis be a method of making the tumour nuclear iso-antigens immunologically ineffective by previous immunization with a related lipo-protein cytoplasmic antigen. Cells thus selected with a greater surface concentration of the 'cephalin'-protein complex would be automatically protected from the normal nuclear immune mechanism and thus enhancement would be permanent, but only in the strain in which enhancement was originally induced. Under such conditions blocking antibody would continue to be elicited by excess surface antigens. Remote enhancement occurs even after removal of the enhanced tumour, for so long as effective antibody is in circulation enhancement will occur.

Enhancement can be regarded as a state of greater malignancy corresponding to the normal but slower progression of the transplanted tumour toward greater freedom from immune attack, when it exists. If natural selection is occurring, those cells containing more enhancing antigen appear gradually to predominate. This gradualness suggests that 'enhanced' tumour cells are held in check by less rapidly growing cells just as seems to occur in the experiments cited. The mechanism of this remarkable check is not clear. It may be due to a more powerful lethal antibody response to unenhanced cells overwhelming locally enhanced cells, though admixture with cells of normal organs is without effect. It may be a manifestation of an auto-regulatory control, in which surface antigens from less malignant cells in close contact with more malignant cells restrain growth by passage into or on to such cells and thus transforming them. However, the restraint in a normal mixed tumour cell population gradually weakens, as usually a more malignant cell race gradually preponderates. Slow progression to increasing autonomy is a feature of malignancy. Even the increased rate of cell proliferation in the early stages of carcinogenesis may prove to be the first step in enhancement towards neoplasia.

In this connexion it is of interest that certain substituted carcinogens (for example, the 9-amino, 9-nitro and 9-*iso*cyanate derivatives of 1-2-5-6 dibenzanthracene), instead of being tumour inhibiting like the parent compounds, actually accelerate growth. Even a normally powerful non-carcinogenic tumour inhibitor (for example 11–12 benzfluoranthene) may, in the presence of a high natural immunity, abrogate this immunity[10]. Is it possible that the antigenic nature of the protein-bound substituted compound is sufficiently different from that of the parent carcinogen as to elicit an antibody blocking, instead of reinforcing, the action of tumour-induced antibody ? There is an indication here not only that carcinogenesis involves an immune process but that its mechanism may even be related to that of tumour enhancement.

What bearing have these findings on the immunological theory of cancer[7,11–17] ? This ascribes neoplastic change to a loss of immunological identity in the cell. The theory embraces the idea that cytoplasmic tissue-specific antigens (lipo-protein complexes), rather than nuclear iso-antigens, are involved primarily. A clue to the nature of such tissue-specific antigens is provided in our enhancing experiments. Although enhancement is obtained with normal tissue or tumour phosphatide from another species (mouse to rat), the effect is about doubled by using isologous tumour phosphatides which confer greater tissue specificity on the antigenic lipo-protein and thus appear to stimulate a greater output of tumour-specific antibody by living tumour. So cytoplasmic 'cephalin' seems to show definite tissue-specificity.

Both certain choline-containing phosphatides and some factor(s) in tumour soluble protein fractions stimulate resistance to tumour growth. This increased immunity could be due to antibodies to cytoplasmic lipo-proteins which do not block the effect of the nuclear iso-antibody but reinforce it. A very active factor possibly of this nature is precipitated from the soluble proteins by glutathione treatment. This treatment also preserves the strong hæmagglutinating action of the extract, which otherwise rapidly disappears. The tissue 'cephalin' phosphatides are exceedingly surface active and produce hæmagglutination at very high dilution[6,7]. The choline-containing phosphatides have no such action and some fractions inhibit the 'cephalin' effect. Now the soluble proteins from a wide range of tumours strongly agglutinate red and other cells, whereas very few normal tissues do and then more feebly. Moreover, mouse skin acquired this property during the course of chemical carcinogenesis. The agglutinating factor in tumours is found in the lipo-protein fraction containing the enhancing factor, and free sulphydryl groups are important in both actions. These and other facts[17] suggest that 'cephalin-containing' lipo-proteins are particularly prominent in malignant tumours and reflect a change starting early in carcinogenesis. There is some chemical evidence of this, for in a rat hepatoma there was[18] a significant increase in 'cephalin' mainly in the cytoplasm, with a decrease in lecithin, and in a mouse breast tumour more 'cephalin' and less lecithin than in resting or pregnancy-stimulated breast tissue were found[19].

The different growth potentialities of the cells in one tumour may reflect differences in the amount of 'cephalin'-protein complexes at the cell surface. There is firm evidence that progressive deficiency in a soluble protein fraction occurs during carcinogenesis and some evidence that a lipo-protein is involved[17]. We would therefore speculate that the missing proteins are of a type bound to choline-containing phosphatides and that their loss is accompanied by a relative or absolute increase in those bound to 'cephalin' phosphatide.

If lipo-protein imbalance is related to malignancy then we have to consider how the change is initially brought about. We have shown[7,11–17] how malignant properties could be accounted for by loss of tissue-specific antigen(s). The inducing mechanisms, according to theory, include an immune attack of the host provoked by a chemical- or radiation-modified tissue-specific protein complex and nutritional competition or deficiency due to the action of hormones, viruses or the conditions of tissue culture. It was postulated that in chemical carcinogenesis the initial change is the formation of a tissue-specific auto-antigen and this may prove to be true of many forms of tumour induction. The well-known fact that chemical carcinogenesis is inhibited in the absence of free SH groups in the tissue may be linked to a similar relationship to antigenic and hæmagglutinating activity in tissue lipo-proteins. Other, possibly lethal, immune reactions may occur as the result of non-specific binding or alteration of nuclear antigens. Antibodies to cytoplasmic lipo-protein antigens are less lethal and thus may be able to induce a progressive adaptive loss of such antigens. On the basis of current work, loss of a membranous lipo-protein complex containing a phosphatide of the lecithin type can be envisaged. This is obviously speculative but any clue to the site of specific binding by a carcinogen has value. It embraces the idea that the tissue-specific antigens concerned are 'lecithin' (choline-containing) protein complexes. It is significant that chronic choline deficiency itself[20–23] will induce cancers of the liver and other sites, and tumour formation due to this[24] or to butter yellow feeding is prevented by riboflavin. This suggests that a choline phosphatide is involved, particularly as dietary ethanolamine also strongly inhibits azo dye carcinogenesis[25], and dietary ethionine induces liver tumours[26], possibly, we suggest, by blocking choline synthesis. Moreover, liver tumours are unable to condense formate with glycine and then decarboxylate serine[27], which may be another pointer to a disturbed phosphatide balance. Another possibly relevant point is that admixed lecithin in excess has an anti-carcinogenic effect[28], which could be due to deviation of the carcinogen to a non-specific lecithin protein complex. It was suggested[13,14] that tumour induction by hormonal excess or tumour promotion by substances like croton oil, 'Tween 60' or certain viruses could be a result of nutritional deficiency. Rapid cell proliferation is accompanied by a big increase in phospholipid turnover and its long perpetuation in a damaged tissue could theoretically lead to local deficiency in an essential factor (for example choline) in phosphatide synthesis. Similar events could account for malignant transformation in tissue culture. A direct tumour virus like the Rous is rich in phospholipid, and a close chemical affinity of virus to cytoplasmic lipo-protein might enable it to replace competitively a tissue-specific substance. Many speculations on these lines could be made and are useful if only to attract attention to the possible role of phosphatides in carcinogenesis. Despite their surface active properties and the fact that lipo-protein forms a basic part of normal cell membranes, they are almost neglected in the cancer problem.

We have reasoned that tumour enhancement is made possible by an altered chemical structure of the cell membrane peculiar to cancer. If such an alteration exists, it presumably begins early in carcinogenesis, with a progressive loss of certain choline-containing lipo-proteins until the cell identity is sufficiently altered to enable it to evade homœostatic growth controls. Progressive adaptation results in all the carcinogen-induced auto-antigen being lost from the cell; the cancer cell therefore elicits no immune response from the host, and an immune reaction, if any occurs, is one of the tumour to the host[12]. We have discussed[7,11–17] how lack of tissue-specific antigen(s) could account for the anaplasia, invasiveness and rapid growth of the cancer cell. There are several factors involved here, but, if the concept of Weiss[29] is valid that diffusible substances from the mass restrain the growth of similar cells, then tissue-specific substances must be the receptors for these auto-regulatory as well as the endocrine hormones. Possibly organized growth is controlled by a process which on further analysis will be explicable in immunological terms.

The suggested chemical alteration could also account for the decrease in basic proteins[30] in the cancer cell, and the fact that the specific azo dye binding is chiefly to protein of similar type[31]. The present work suggests that there is an alteration in the lipo-protein orientation of the membrane of the cancer cell. If this involves a deficiency of lecithin and an excess of 'cephalin' in certain lipo-protein complexes, it could account for lack of adhesiveness and contact inhibition[32,33]; for an increased negative surface change[34,35], due to a greater content of the more acid and a smaller content of the more basic phosphatides, could account for the greater repulsion of cancer cells one from another.

The work on enhancement, as well as many other lines, stemmed from considerations of the immunological theory. It strongly suggests that lipo-proteins are important cytoplasmic antigens and indicates that certain proteins of this class are deficient in the cancer cell. However debatable many of the present ideas may be they all point to some abnormality in phosphatide configuration as being a feature, possibly the dominant one, of neoplasia.

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OBITUARIES

Prof. F. O. Lawrence

The recent death of Prof. Ernest Lawrence of the University of California, Berkeley, brought to a close the active career of one of the greatest figures in the world of science. Prof. Lawrence had contributed to modern physics a tremendous amount of new knowledge and had advanced its frontiers at an unprecedented rate. This rapid extension was no accident, for he was abounding in ideas and the energy and drive needed to overcome the many obstacles in the way of progress. His enthusiasm, skill and originality were each and all of the highest category.

Yet it is interesting to note that physics came near to losing its great exponent. Many fond memories come to my mind from the period of nearly two years that I worked with him in the Radiation Laboratory, and I recall the surprise that I felt when he told me how as a young research student at Yale he had doubts as to his capacity for original work. The doubts were overcome when the then grand old man of American physics, Michelson, visited the laboratory. Michelson did not try to hide his own ignorance of the ideas involved in Lawrence's studies. In turn Lawrence was inspired to stay in the field to which he was soon to contribute on a vast scale. Lawrence laughingly remarked that if one could reach eminence without knowing everything, then perhaps he himself was not so ignorant as he had imagined.

At twenty-nine years of age he became the youngest full professor at Berkeley and director of the Radiation Laboratory. As such he stood in the forefront of nuclear physics for some thirty years. Like Michelson, he never shirked placing himself in the position of a learner, and the many still younger men who served with him had great pleasure in telling him of their successes or failures. His interest in their work was complete, and unstintingly he contributed his own ideas to advance their studies. It is easy to appreciate how he acquired the gratitude and affection of a long line of distinguished scientists who studied with him. The laboratory on 'The Hill' became a veritable Mecca to keen physicists and a succession of Commonwealth Fellows and others became part of the organization which was so peculiarly his own and which was so well adapted to prosecuting the most advanced studies in perhaps the most difficult field of modern science.

The cyclotron is inevitably linked with Lawrence's name, and many institutions are deeply in his debt for the unfailing assistance that he gave in their efforts to equip themselves with one of his machines. Yet it was but one of the many amazing tools fashioned by Lawrence and his team and brought to bear on the problem of the nucleus. Lawrence was a remarkably inspiring teacher, one who in a few words could throw light on a whole field. Much of this ability came from his own deep insight, which allowed him to create for himself 'models' serving a similar purpose to, say, Bohr's model of the atom. Yet he was at home in the company of the most erudite theorists, and had little difficulty in discussing with them the most advanced theories. He was always the inspiring leader—the only essential was some sign in the young researcher of at least a pale reflexion of his own enthusiasm for his favourite subject. Young scientists came to him eagerly and in his own words he "found the genius of men spread rather uniformly over the entire globe". Many later put his methods into practice in their own lands, and so his gifts were multiplied and are still being multiplied.

It is difficult even to enumerate the many discoveries linked with Lawrence and his Laboratory. A host of new radioisotopes were investigated, among them tritium, radiocarbon, uranium-233 and plutonium. Indeed, twelve synthetic elements like plutonium resulted from work at Berkeley. The first laboratory generation of mesons and anti-particles took place there.

Much of his work is of immediate moment to the well-being of mankind. Radioactive tracers and neutrons were applied in biology and medicine, he and his brother John taking the role of pioneers. More directly still he gave of his best in the Second World War when he pushed to a successful conclusion the Calutron project, something which perhaps none but he might have believed possible. He saw the nuclear power age as one which would free miners and others from their toil for coal. Always he sought to raise the standards of living for all. On an international scale he served with the Stassen Committee, and he was at Geneva working towards agreement on the detection of nuclear explosions when illness overtook him.

He lived his life at a tremendous pace and to one who gave all there rightly came many high honours. He was a Nobel laureate, he held the Comstock Prize of the National Academy of Sciences, the Medal for Merit of the United States Government, the American Cancer Society Medal, the Enrico Fermi Medal of the Atomic Energy Commission, the Faraday Medal of the Institution of Electrical Engineers, the Hughes Medal of the Royal Society and the Duddell Medal of the Physical Society. He was an honorary doctor of many universities, including Yale, Princeton, Harvard, Michigan, McGill, British Columbia, Glasgow, and an honorary Fellow or member of societies including the Academy of Science of the U.S.S.R., the Indian Academy of Sciences, the Royal Swedish Academy of Science, the Royal Irish Academy of Sciences, the Royal Society of Edinburgh.

Ernest Lawrence is one of those whose loss is grievous but relieved by the fact that his inspiration lives after him in the memories and works of the many so deeply in his debt. S. C. Curran

Prof. Maurice Caullery, For.Mem.R.S.

Maurice Caullery, honorary professor at the Sorbonne, where he occupied during thirty years the "Chaire d'évolution des êtres organisés", died on July 15 at the age of ninety.

The eminent scientist, to whom zoology owes so many contributions, had been a student at the École Normale Supérieure, where he was a pupil of Alfred Giard. His thesis dealt with the histological phenomena accompanying the seasonal regression and development of Synascidia, and led to the conclusions that the tissues of various organs (nervous system, peribranchial cavity) are ectodermal in the oozoids, whereas, in the blastozoid, they originate from the internal vesicle of the bud, and thus, in the last analysis, from an endodermal tissue. The very same organ might thus be derived from two different 'feuillets'. This unexpected conclusion was the starting point of a comparative study of budding in various Synascidia, and, in particular, in the Didemnidae, where the essential role of the epicardic tube in blastogenesis was discovered.

The Microniscidae were known as parasites of planktonic copepods. Caullery succeeded in demonstrating that they are an intermediate phase between the epicaridic and the cryptoniscian larvæ (epicarids are isopods parasitic on other crustaceans). The study—with Félix Mesnil, who became his brother-in-law—of the cryptoniscian *Hemioniscus balani* revealed the existence of a protandric hermaphrodism. It turned out that this was a general feature of the group : all the cryptoniscians are first males, then females. Caullery and Mesnil also discovered and described a parasite of annelids, *Xenocoeloma brumpti*. The central cavity of this copepod is covered by the peritoneal endothelium of the host, an extreme case of parasitic degeneration.

A number of wandering annelids were known to undergo metamorphosis at the time of sexual maturation, and the altered 'epigamic' worm disseminates the sexual elements. The study of *Dodecaceria concharum* revealed that epigamy also occurs in tubicolous annelids. The discovery by Caullery and Mesnil originated in numerous investigations which revealed unexpected traits in the life-cycle of polychæte worms.

These two French zoologists disclosed the entire life-cycle of orthonectids. The plasmodia of *Rhopalura ophiocomae*, a parasite in *Amphiura squamata*, give rise to germ cells which are the origin of the males and females. These escape from their host ; copulation and fecundation take place, and ciliated larvæ are produced which, when freed, infect a new *Amphiura* and give rise to plasmodia, thus initiating a new cycle.

The invertebrates of the French coast of the English Channel are rich in parasites and especially in parasitic Protozoa. Caullery and Mesnil discovered a new gregarine, *Gonospora longissima*, which provided the first example of schizogonic reproduction in the group. Moreover, it was found that the various phases of the life-cycle of the parasite are controlled by the phases of the life-cycle of the host. This was perhaps, in 1898, the first example of such a type of interaction.

The study of the actinomyxidium *Sphaeractinomyxon* revealed the existence of a new type of sexual process and was the first example of sexuality in the *Myxosporidia*. Finally, Caullery and Mesnil studied or discovered a number of Protozoa, such as the *Metchnikovellidae*, parasites of the cytoplasm of gregarines, the *Siedleckia*, parasites in the annelids : and they created the group of Haplosporidia for a number of Sporozoa the relationships of which they were able to establish.

Maurice Caullery never failed to give his own studies their proper place in a great ensemble. Having studied so many parasites, he naturally was led to write a book on parasitism, "Le parasitisme et la symbiose" (Doin, 1923), now translated into English. His lectures on various biological subjects were also published in book form and exemplify his erudition and critical sense : "Les Problèmes de la Sexualité"

(Flammarion, 1918), "Les Problèmes de l'Évolution" (Doin, 1931), "Les Conceptions modernes de l'Hérédité" (Doin, 1935), "Les Progrès récents de l'Embryologie expérimentale" (Doin, 1939), "Organisme et Sexualité" (Doin, 1942).

These books reflect the excellence of his teaching, which influenced numerous young scientists. A number of them have made brilliant careers in experimental biology and embryology and developed schools of their own.

Maurice Caullery was, in 1928, elected to the Paris Academy of Sciences and in 1948 he was elected a foreign member of the Royal Society. He was also associate or corresponding member of numerous other foreign academies.

Up to the time of his death, Maurice Caullery remained physically and intellectually alert, walking every day to the laboratory, continuing to read and to write. In 1945 he became president of the Academy of Sciences, and, in his presidential address, did not hesitate to denounce its ageing and immobilism, fighting with acidity and vigour for a renewal of its organization. A great sense of duty and devotion to science associated with intellectual youth and vitality were among the characteristics of Maurice Caullery. Throughout his long life, he devoted himself to the advancement of biology.

He is survived by Mme. Caullery and their four children and numerous grandchildren.

ANDRÉ LWOFF

NEWS and VIEWS

The American Air Force Lunar Probe

THE American Air Force lunar probe attempt on October 11 failed to achieve the full objective of a circum-lunar orbit, but demonstrated that many of the technical problems of launching and accelerating a three-stage rocket to the necessary speed have been solved. Guidance of the rocket into the correct path and precise control of the final cut-off velocity appeared to have been the chief problems not yet completely mastered. The tracking of the rocket and reception of telemetry signals both in the United Kingdom and at other stations was very successful out to the maximum distance of almost 80,000 miles from the Earth's surface. In the instrument payload of some 40 lb. were included radiation detectors, which confirmed the earlier measurements on *Explorer* IV of the intense radiation belt surrounding the Earth. Preliminary analyses of the results have shown a significant decrease in intensity beyond several Earth radii, and seem to confirm the idea that the radiation is due to the trapping of cosmic particles by the Earth's magnetic field. Temperature and micro-meteorite impact measurements should give valuable data on conditions in regions now explored for the first time. No doubt there are some who will not regret the failure to penetrate the mystery of the Moon's unseen face, but it must be only a matter of time until this is done; meanwhile, the progress already made and the value of the scientific measurements obtained merit warm congratulations to the American scientists concerned.

Racial Problems in Britain

THE Eugenics Society (69 Eccleston Square, London, S.W.1, 1*s*. 6*d*.) has recently issued the first of a new series of broadsheets, which deals with the subject of West Indian immigration into Britain. In the preface, Sir Charles Darwin explains that the aim is "to review the whole position, so that whatever the reader's final conclusions may be, they should at least be based on fact and not on mere emotion". Recent events in Great Britain have made it plain how important this is; but it is also obvious from the paper itself, written by Mr. Colin Bertram, the general secretary of the Eugenics Society, that the separation of facts from opinions concerning the problem of 'race' is a task of the greatest difficulty.

It is unfortunate that the argument of the broadsheet involves a large measure of confusion between the social and the genetic aspects of the subject, and that it takes so much for granted. As it is assumed that "miscegenation runs counter to the great developing pattern of human evolution", the onus of responsibility is placed on the shoulders of those who are willing to allow it to continue in Britain. There is, it is said, "a need to ponder" on this difficult issue, "unless there are evident ultimate genetic advantages in the production of persons more likely to be capable, happy and altruistic in the circumstances of the future", as the offspring of mixed marriages. It is improbable, however, that any precise information can now be produced which would indicate whether these somewhat vague requirements can be met. Until the problems of race relations are stated in clearer terms, from the genetic point of view, it is unlikely that what has been termed the 'art of eugenics' can contribute significantly to their solution.

Waverley Gold Medal Essay Competition

THE Scientific Advisory Board of *Research* has awarded the following prizes in the Waverley Gold Medal essay competition. The Waverley Gold Medal and first prize: Mr. A. J. C. Hall (University of Sydney) and Mr. J. G. Hayes (Royal Melbourne Technical College) for "Coloured Patterns in Glass"; second prize, Mr. T. R. Manley (A. Reyrolle and Co., Ltd., Newcastle upon Tyne) for "The Irradiation of Plastics"; special prize for an author under thirty: Mr. M. D. Lilley (Aplin and Barrett, Ltd., Yeovil) for "Food Preservation with the Antibiotic Nisin"; highly commended: Mr. J. Heywood (Norwood Technical College, London) for "Radio Astronomy—an Aid to Education". The prizes will be presented to the winners on December 15 at 6 p.m. in the lecture hall of the Royal Society of Arts, John Adam Street, London, W.C.2.

Industrial Training Council

THE Industrial Training Council, which consists of representatives of the British Employers' Confederation, the Trades Union Congress, the nationalized industries, Government departments and educational bodies, and recently held its first business meeting, has the primary function of encouraging individual industries to take action to ensure a satisfactory level of industrial training. The point was emphasized that it is only the organizations in the individual industries that have any executive authority. It was decided, as a first step, that the Council should seek factual information from the industries as to their future needs and opportunities for training personnel. The Council agreed that industries should first be encouraged to undertake the assessments—suggested by the Carr Committee—as to their future man-power needs and to compare these with existing facilities for training. It was stressed in particular that there is an urgent need for each industry to make some quantitative assessment to satisfy itself that its training arrangements will be adequate to meet the coming 'bulge' in school leavers. The Council further decided to ask each industry to state in general terms how far, if at all, it has dealt with the main recommendations in the report of the Carr Committee which cover the whole field of training of young workers.

Graduate Training in Chemical Engineering

It has been realized for many years that a student who has obtained a degree in engineering at a university is by no means fully equipped to take his place in an industrial concern, and many large firms have organized training courses of a practical nature which supplement the fundamental and more theoretical knowledge acquired at the university. In chemical engineering, owing to the diversity of subjects dealt with, it is not easy to decide the exact form which such courses should take, and in view of the increasing demand for guidance in this matter, the Education Committee of the Institution of Chemical Engineers, after consultation with the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers Association, has now published a brief advisory note. In this it is pointed out that it seems desirable for every chemical engineering graduate to have practical training in four main subjects—the design, fabrication, development and operation of process plant. Two years is suggested as the total period of training, but the time allocated to each subject should vary substantially according to the type of work which the trainee is intended to take up. During the training it should be possible to emphasize such subjects as costing, labour management, safety and report writing. A schedule in somewhat greater detail is given. Twenty-seven large organizations are at present operating training schemes which conform with these suggestions and the note should prove very helpful as a guide to firms which are contemplating the introduction of organized postgraduate training into their business.

Building Research

The latest reports of the Building Research Board and of the Director of Building Research of the Department of Scientific and Industrial Research have been published in a booklet entitled "Building Research 1957" (pp. iv+75+16 plates. London: H.M. Stationery Office, 1958. 5*s*. 6*d*. net). These reports are of special topical interest following the recent criticism of the annual report of the Building Research Station by the Select Committee on Estimates in the course of its inquiry into the finances of the Station; the Committee complained that the report was of too general a nature to be of much value to those interested in the work of the Station. Opinions will, no doubt, differ on this point, but all familiar with the building industry will appreciate the difficulties facing the Director in compiling his report.

In order that the Building Research Station should be in a position to view all building problems in their correct perspective, the programme of work undertaken is very broad, ranging from rheology to the packaging of bricks. The Station is, nevertheless, able to make a number of contributions to basic research in several fields. For example, the high-temperature microscope, described in the report for 1956, has been further developed and a new instrument has been constructed which permits observations to be made in special atmospheres at temperatures exceeding 2,000° C. Further contributions have arisen out of the Station's work on lighting and heating, and an investigation of the aircraft-noise nuisance problem has given rise to some basic research on sound propagation in the open air.

Cancer and Mental Health in 1952–53

The Registrar General has recently issued two supplements to his Statistical Review (Supplement on Mental Health for 1952–3. Pp. xi+208. 11*s*. 6*d*. Supplement on Cancer for 1953. Pp. xi+105. 7*s*. 6*d*. London: H.M. Stationery Office, 1958). The cancer volume is a continuation of previous studies, discussing figures obtained from the cancer registration scheme for eight further sites: in women, the corpus uteri and ovary; in men, the testis and penis; and in both sexes, lip, tongue, mouth and pharynx, and the œsophagus. New registration-rates and mortality-rates are presented for each site, and there are figures showing mortality in each year of treatment and the five-year survival-rate in relation to the clinical state of the disease at registration and by method of treatment, and there is a text section commenting briefly on the principal results.

The supplement on mental health is more comprehensive. It gives figures relating to the population of patients in mental hospitals and mental deficiency hospitals, the duration of stay and the incidence of mental disease, as measured by new registrations, among different groups of the population. The figures are divided by age, marital status and occupation. The period considered is too short for significant trends to emerge, but it might be noted that between 1950 and 1953 the median duration of stay for patients discharged from mental hospitals steadily decreased. The incidence of mental disease is particularly high among the single, and in Group V, the lowest group of the Registrar General's classification. Adverse rates of mental disease also seem to be connected with a high standard of education, clerical and domestic work, labouring and branches of the catering industry, but the Registrar General recognizes that in this field it is difficult to disentangle cause and effect and that further ecological studies are required.

The Neolithic Age in Eastern Siberia

The new volume of the *Transactions of the American Philosophical Society* (New Series, 48, Part 2 (1958): "The Neolithic Age in Eastern Siberia". By Henry N. Michael. Pp. 108. Philadelphia: American Philosophical Society, 1958. 2.50 dollars) will be much welcomed by prehistorians. Here in the West it is not too easy to obtain accounts of investigations made in Siberia, especially as many of the articles are written in Russian. Some little while ago there was a short article on "Eskimo Archæology" by H. B. Collins which appeared in the *Proceedings of the American Philosophical Society*. But this only touched on some of the early stone age finds near Lake Baikal and farther to the north. Merhart's well-known work on the Siberian Palæolithic cultures deals, of course, with discoveries of an earlier period. "The Neolithic Age in Eastern Siberia", therefore, fills a yawning gap in our knowledge of the region. The reader will do well to turn to Table 2 on p. 33 and to read the accounts of the finds in the light of the chronological sequence there set out. Not everyone agrees as to the origins of these various cultures. Fundamentally, however, it would seem that a case has been made out for connexions with the west, for example, with such an area as south Russia. Whether the Magdalenians, drifting north and east following the reindeer and retreating before the ameliorating climate of western Europe, ever reached Siberia is very uncertain, though the possibility should not be ruled out. Anyway, there seems to occur a sort of late Palæolithic–Mesolithic complex and this is followed by a transitional (Khina) culture which in turn heralds the early Neolithic industries (Isakovo) with some pottery and polished stone tools. Naturally in such an isolated region local developments occur. There follow the various Neolithic cultures, and after them those of the true Bronze and Iron Ages. Many of the ideas put forward are necessarily tentative, but the volume does bring up to date what is known of the earlier Stone Ages of these remote regions.

New Vaccine for Fowl Typhoid

A NEW immunizing agent for use against fowl typhoid is now available to the poultry industry. Following initial work by Dr. H. Williams Smith, an Animal Health Trust bacteriologist, on the organism causing this costly and highly infectious disease, the Trust has evolved a 'live' vaccine the efficiency of which has been thoroughly tested and proved in a series of field trials carried out in collaboration with the Veterinary Investigation Service of the Ministry of Agriculture. Prepared from a strain of the organism which is less virulent than most, the new vaccine, known as '9 *RS*', is free from the drawbacks associated with the use of earlier 'live' products—the risk of setting up active disease in the field, and the liability to cause reactions inimical to the success of normal blood-testing for both B.W.D. and fowl typhoid itself. It is therefore completely safe, and supplies for home administration are now offered for sale to all poultry-keepers. It is emphasized that the purpose of the vaccine is to prevent fowl typhoid. It is not a cure. As an illustration of its preventive power, it was shown in one trial that, of a group of birds vaccinated with 9 *RS* and later artificially infected with fowl typhoid, only 6 per cent died, whereas a similar group of unvaccinated birds suffered a 70 per cent death-rate. Further information can be obtained from the Animal Health Trust, Biological Products Department, Kennett, Nr. Newmarket, Suffolk.

Sputniks 1 and 2

MUCH of the preliminary orbital data on the first two *Sputniks* obtained by staff of the Smithsonian Astrophysical Observatory up to March 1958 is collected in *Smithsonian Contributions to Astrophysics* (2, No. 10 : Orbital Data and Preliminary Analyses of Satellites 1957 Alpha and 1957 Beta. Compiled by F. L. Whipple, L. G. Boyd, J. A. Hynek and G. F. Schilling. Pp. vii+189–347. Washington, D.C.: Government Printing Office, 1958. 1 dollar). The aim of the compilation is to publicize the orbital information as quickly as possible, and the various items are printed unrevised. The volume is thus a historical record rather than a critical survey, and many of the early orbital determinations, which were inevitably erroneous, are given equal emphasis with later and more accurate computations. This should be borne in mind when reading the volume, the contents of which are rather varied. There are a good deal of orbital information and a useful glossary of astronomical terms. There are lists of the optical observations of the satellites made by 'Moonwatch' teams, and of the daily predictions transmitted by Moscow radio. There are also two papers giving values of upper-atmosphere density deduced from the *Sputnik* observations, and the suggested 'interim standard atmosphere No. 2' has, in fact, successfully fitted the results from later satellites.

Medical Electronics

A RECENT meeting of an interim committee composed of members of the Institution of Electrical Engineers and of the medical profession having a common interest in medical electronics discussed the scope and future activities of the Medical Electronics Discussion Group, which has been set up by the Institution of Electrical Engineers. An organizing committee, responsible for arranging the programme of the Group, was appointed under the chairmanship of Mr. S. J. Emerson. It was decided that the activities of the Group should be centred around advanced electronic techniques applied or related to medical and biological problems, and there will be a programme of informal discussion meetings which will provide a forum for the exchange of information between the two professions on subjects coming within this field.

The first meeting of the Group is to be held at the Institution of Electrical Engineers at 6 p.m. on November 7, when Dr. A. C. Dornhorst (St. Thomas's Hospital Medical School) will speak on "Measurements of Blood Flow in the Human Subject", and Dr. D. A. McDonald (St. Bartholomew's Hospital Medical College) will speak on "Measurement of Pulsatile Blood Flow". A second meeting will be held on November 28 to discuss the problems which are encountered in the field of neurophysiology, when the speakers will be Dr. Warren S. McCulloch (Massachusetts Institute of Technology) and Dr. W. K. Taylor (University College, London). A third meeting in January 1959 will deal with "The Physiologists' Requirements for d.c. Amplifiers". It is proposed to provide an opportunity at each discussion meeting for members to give notice of any problems they have encountered (not necessarily related to the topic discussed at the meeting), in the hope that others present may be able to offer suggestions for their resolution. Further information can be obtained from the Secretary, Institution of Electrical Engineers, Savoy Place, London, W.C.2.

Department of Scientific and Industrial Research, Research Fellowships

THE following fourteen research fellowships have been awarded by the Department of Scientific and Industrial Research for the academic year 1958–59 to young research workers of exceptional promise who, usually, have already received postgraduate training up to the level of a doctorate : C. J. Batty (nuclear physics, Birmingham), L. B. Tarlo (palæontology, British Museum), J. Biggs (chemistry,

Cambridge), Dr. Enid R. C. MacRobbie (biophysics, Cambridge), Dr. C. J. S. M. Simpson (chemistry, Cambridge), A. K. Kent (zoology, Bedford College, London), R. M. E. Sullivan (engineering, King's College, London), Dr. Amy M. Goodall (chemistry, University College, London), G. Culligan (nuclear physics, Liverpool), P. D. Forsyth (nuclear physics, Manchester), F. H. Read (nuclear physics, Manchester), W. R. Phillips (nuclear physics, Oxford), B. Nicholls (chemistry, The Queen's University, Belfast), G. E. Hall (chemistry, Technische Hochschule, Zurich).

Lalor Foundation Grants

The Lalor Foundation has announced the programme of awards for 1959 which it is offering to college and university faculty members for research in the biological sciences. These awards are to be for support of research on the fundamental biochemical and biophysical mechanisms concerned with fertility and reproduction in various forms of life. The objectives are to work for more complete understanding of the basic phenomena involved and ultimately toward better possibilities for biological regulation and control. Grants may range up to 8,000 dollars per year and will be scaled in proportion to the scope and duration of the projects approved. Preference will be given to younger members of university and college staffs with an upper age-limit of forty-five years. The work may be carried out at the applicant's own institution or elsewhere. The Foundation will also grant postdoctorate summer or short-term research awards in the field described on projects which, for example, would be appropriate to the Marine Biological Laboratory at Woods Hole, Mass., or elsewhere. For these awards, the stipends will normally not exceed 900 dollars for a single man or a woman, 1,100 dollars for a married man working at his home institution, and 1,250 dollars for a married man with his principal programme at another institution. Application and inquiries should be directed to the Lalor Foundation, 4400 Lancaster Pike, Wilmington 5, Delaware, and applications must be received by January 15, 1959.

Bedson Club Lectures

The programme of lectures of the Bedson Club, King's College, Newcastle upon Tyne, during 1958–59 will be: October 31, Prof. R. A. Raphael, "The Acetylenic Approach to the Synthesis of Natural Products"; November 21, Prof. H. C. Longuet-Higgins, "Recent Developments in Quantum Chemistry"; January 23, Prof. E. G. Cox, "The Molecular and Crystal Structure of Benzene"; February 20, Dr. R. E. Richards, "Recent Developments in the Chemical Applications of Nuclear Resonance Spectroscopy". The following lecture will be given in association with the Royal Institute of Chemistry: November 7, Dr. J. Harris, "From Barley Corn to Bottle". The following lecture will be given in association with the Society of Chemical Industry: January 16, Dr. E. R. Wilson, "An Industrial Approach to Basic Research: Fabric Substantive Fluorescing Agents". The lectures will be given at 5.30 p.m. in the Chemistry Department.

Announcements

Dr. Harold Moore, director of the British Non-Ferrous Metals Research Association during 1932–44, has been elected an honorary member of the Iron and Steel Institute, of which he has been a member for fifty-seven years; of the twelve living honorary members of the Institute, only one other, Sir William Larke, is British.

Mr. M. G. Morris (Cambridge) has been awarded the first V. H. Blackman Postgraduate Research Studentship, of £500 per annum for three years and tenable at East Malling Research Station, for research in applied entomology.

The annual general meeting of the Association of Clinical Biochemists was held at the Royal College of Surgeons, London, on October 4. The following officers were elected for 1958–59: *President*, Prof. E. J. King; *Chairman*, Dr. A. L. Latner; *Honorary Treasurer*, Dr. J. H. Wilkinson; *Honorary Secretary*, Dr. A. L. Tárnoky, Royal Berkshire Hospital, Reading.

The Education Panel of the Corrosion Group of the Society of Chemical Industry will again award a prize for an essay on corrosion science by a young author, less than twenty-seven years of age by the closing date, March 31, 1959. A length of about 4,000 words is suggested. Further information can be obtained from Corrosion Group Essay Competition, c/o Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

Full-time and part-time courses in polarography organized by the British Polarographic Research Institute will be available during the session commencing November 1958. Further information can be obtained from the secretary, Mr. W. J. Parker, 55 Oriental Road, Woking, Surrey.

The Northern Branch of Aslib is arranging a symposium on "Practical Aspects of Special Library Work" in Sheffield on November 27 and 28. Further information can be obtained from Miss E. Boddy, The Retreat, Tideswell Lane, Eyam, Nr. Sheffield.

A conference on "Fuel and Power in British Industry" organized by the Manchester Joint Research Council is to be held in the Manchester College of Science and Technology during November 5–7. Sessions will be devoted to resources and utilization of coal and of oil, to nuclear power and to electricity. Further details may be obtained from the Joint Hon. Secretaries, Manchester Joint Research Council, Manchester Chamber of Commerce, P.O. Box 559, Manchester, 2.

The autumn meeting of the Parasitology Group of the Institute of Biology will be held on October 24, in the rooms of the Royal Entomological Society, 41 Queen's Gate, London, S.W.7. The morning session will be devoted to "Chemotherapy of Parasitic Diseases", followed in the afternoon by a discussion of "The Problems of Publication", from the points of view of editor, publisher and contributor. The meeting will be open to non-members. Further details can be obtained from the honorary secretary of the Parasitology Group, Dr. June Mahon, Department of Zoology, Bedford College, Regent's Park, London, N.W.1.

Erratum. In the communication entitled "'Crossing' Paper Electrophoresis for the Detection of Immune Reactions", by Prof. S. Nakamura and T. Ueta, published in *Nature* of September 27, p. 875, in Fig. 1*A* the line labelled *Ab* should be labelled *Ag* and *vice versa*.

CONTEMPORARY PROBLEMS IN MATHEMATICAL TEACHING AND STAFFING

It is now generally recognized that, in the drive to meet the modern needs of Great Britain on the industrial side, many new problems are emerging in relation to the creation of the necessary scientific and technological personnel. Two of these, in particular, arise out of the comparatively recent appreciation of the fact that mathematics has moved into a central position in the study and development both of science and of technology. There is scarcely a sector of these that is not leaning more and more on mathematical techniques. This, therefore, poses a new task to the mathematical profession; and those who are concerned that it should be effectively carried out can see at once the two problems that stand out sharply. One relates to the content and mode of presentation of the subject-matter that must be taught both at school and at university. The other is concerned with the supply of teachers with mathematical qualities adequate to the new tasks that face the profession. It is therefore not at all surprising that at almost every scientific gathering these two issues come up for discussion.

Section A (Mathematics) jointly with Section L (Education) of the British Association meeting in Glasgow devoted the whole morning of September 2 to precisely these questions. Mr. W. J. Langford, president of the Mathematical Association, presented an interesting survey of the history of the movement for reform of mathematical teaching at schools, from the days when "Euclid" constituted the mathematical Bible, to the modern many-sided approach, where it is possible to dip into the calculus at a relatively early stage. Now, however, the problem has sharpened in another way. As the universities strive to carry their final-year students right to the frontiers of knowledge in this rapidly developing field, the schools are expected to keep pace with what must inevitably be a rising standard of entry, unless, indeed, the period of university study is itself correspondingly lengthened; and this is occurring at a time when apparently less than one-third of those engaged in the teaching of mathematics at school have specific qualifications in this subject. Mr. Langford indicated the possibility that in the near future there may be established an institute of mathematics, comparable to the engineering institutes, which might offer a qualification capable of being acquired by teachers of mathematics who have not reached graduate standard, but are willing to improve their knowledge of the subject presumably while still engaged in teaching.

The dangers inherent in the present position were sharply underlined by Prof. L. Rosenhead, who made a searching survey of our present resources in mathematical personnel, in order to examine how far it might be possible by 1970 to attain to double the number of mathematical teachers that were available in 1955, as hoped for in the present plans. Whether it is consciously visualized or not, for this purpose school and university education is a single process, so that in the last resort the problem of the universities and the colleges in this matter of scientific and technological supply is intimately bound up with what happens in the primary schools. In the U.S.S.R. this has long been recognized, and they are now reaping the advantages of planning on an integrated basis. In Britain, teachers of arithmetic at the primary stage have in general no mathematical knowledge; while again, at the later stages, the potential mathematical interest of the children is often destroyed by the inability of the teacher to awaken the interest of the pupil by opening up to view the wider horizons. At the present moment, there is a frantic search for mathematical school teachers. Since quite a large proportion of those who actually teach the subject have almost negligible qualifications in it, already in some girls' schools the teaching of some branches of mathematics has been given up. In such circumstances, deterioration must inevitably set in.

Prof. Rosenhead asserted that over the past twenty years there had been a definite fall in the level of preparedness at university entry, and if university standards are to be maintained, as they must, the proportion of failures is bound to increase. As a temporary measure he suggested an expansion of the present trend towards the grouping of schools on an area basis for such special teaching, and that no one should be allowed to remain in the sixth form for more than two years. Such expedients, of course, clearly do not get down to the root of the matter, which is the simple fact that those who take high mathematical qualifications at the university are now being attracted elsewhere than into the teaching profession. Industry has within the past decade become conscious of the fact that it is able to use highly skilled mathematicians of almost all kinds—both pure and applied, analysts and computing machine programmers—and the nature of the tasks such mathematicians encounter seem to appeal to them more strongly than the work of the teaching profession. Over and above all this, of course, is the hard fact that salaries are higher in industry. It has therefore become the exception rather than the rule to find mathematical students who are keen on teaching as a career. A generation ago the converse was true. It seems to follow that the standard of mathematical qualification within the teaching profession must deteriorate, so that industry itself will finally begin to experience the effect of the shortage which it is itself helping to create. The fact is simply that there is too small an output of mathematicians to meet the prevailing needs, and the particular advantages that industry can offer tend to canalize those who are produced into that field. In such a situation, the decision as to which is the greater social priority is being left to blind economic forces. As both Mr. Langford and Prof. Rosenhead stressed, in present circumstances the coming generation cannot possibly reach a standard of achievement in keeping with its native ability.

Again the content of, and the approach to, mathematical teaching came under very sharp review. Mr. Langford had pinpointed the successive advances that had been made in school teaching since the "Euclidean" days, and the gradual recognition that mathematics is a single co-ordinated subject, where it is possible to introduce such topics as analytical geometry and calculus long before algebra and geometry had been carried to the limits of school achievement.

Prof. H. Levy dealt mainly with the teaching of applied mathematics, at the university-level, to students of various faculties. He pressed the view that diagrams on paper and blackboard should be realistically seen for what they are—simplified physical 'models' in chalk or carbon particles of actual things. Already, even at this stage, irrelevant elements in the medley of events in the real world have been dropped out, and from this rather grotesque model, sticking to an almost flat surface, it becomes relatively easy for the student to make the mental abstractions we call lines, curves and points. Mathematics, he asserted, deals in the first instance only with these abstractions, and in this way the mathematician sets out to develop a logical deductive system in place of the actual physical process that is being studied. The laws of Nature—Newton's laws, for example—are extracted and abstracted from the medley of real objective events 'out there', and enter as mere mathematical assumptions into the logical analysis. It is important for a student, to see this clearly in order to undermine the 'mystique' of a mathematically derived formula, and to underline the fact that its validity finally rests on verification by observation or experiment, and not merely on logic. In all this, imagination plays a very important part. To construct the appropriate 'model' on paper or blackboard, from the physical sequence of events, requires a considerable effort of the imagination; just as the sense of logical conviction itself rests on a mental scrutiny of imagined alternatives at each step of a proof.

From this point of view Prof. Levy sharply criticized the usual sets of examples and exercises in text-books, in which the author himself has already made the principal geometrical abstraction, expressing it through the phrasing of the question, while the dynamical principle that is to be used in the logic is made obvious from the place of the example in the text-book. While not undervaluing that kind of 'drill', he insisted that teaching and learning are simply two aspects of one process in which both teacher and student are engaged. It follows from this that the teacher must be seen by the student to wrestle with a problem, and, if necessary, to be beaten. The problem must be real, and not a faked-up one designed to come out. Preferably, it should be brought by the student out of his own experience so that the successive steps in forming the abstractions may become apparent. Familiarity with both geometrical and dynamical abstractions plays a significant part in pointing the way towards this reduction of actual physical problems to those of logic. Finally, the precise verbal formulation of the problem in concise terms, as it would appear in a text-book, is itself a crucial educational step. Prof. Levy concluded by stating that in his view it was desirable that every mathematical department should have available as many bits of machines as possible, in order that the student should take them to pieces and re-assemble them, and so seek to isolate the dynamical factors that appear to be in operation during their functioning. In this way the geometrical and dynamical abstractions that require to be made in order to analyse the process from the mathematical point of view would become apparent. This kind of training, consciously applied and consciously appreciated by the student, was essential if he was to play his part *qua* mathematician in modern industry.

Dr. E. A. Maxwell turned to the problem of the teaching of pure mathematics, and in particular he raised the question by what process could the student be encouraged from the beginning to appreciate the importance of rigorous and accurate thinking, and, as part of this, the specific limitations under which the theorems he was using were valid. To this end he stressed the educational value of using the method of contradiction, in a direct form, by 'proving' a number of propositions of the $2 = 1$ type, for the purpose of intriguing the student in the first place. As a consequence, his interest is enlisted in discovering where and how precisely the limitations of the method used have been overstepped. This he illustrated with a variety of examples from a wide range of mathematics. An excellent discussion followed a most interesting morning session.

PHYSIOLOGY AS AN EDUCATION AND AS A CAREER

A JOINT session of Section I (Physiology/Biochemistry) and Section L (Education) of the British Association and of the Physiological Society, held in the Institute of Physiology, University of Glasgow, on September 3, was devoted to a discussion of "Physiology as an Education and as a Career".

In the absence of Prof. A. V. Hill his introductory remarks were read, with evident sympathy and signal effect, by one of his former junior colleagues, Prof. R. W. Gerard, of the Department of Physiology, University of Michigan. Prof. Hill began by recalling what he had said on this topic on several occasions from the 1920's onwards. In these he emphasized the need to free physiology from the bedside attachment of its earlier years and allow it to come in its own right to full stature, as the interpretation of the mechanisms and integrations of normal life. Thus physiology would be brought into a wider service of mankind in the modern fully industrialized State. It has become necessary to spread into new fields the knowledge of the "exquisite structure of the body" and the proper understanding of its functional capabilities and limitations. In all this there is need for first-class brains because in the biological field the data are much more intractable than are those in the inorganic field. This battle for the status of physiology in its own right is slowly being won. Much could be done by capturing early the imagination and interest of the young and securing recruits by means of practical demonstrations and teaching in the schools.

Prof. Hill's Royal Institution Christmas Lectures, later published as "Living Machinery" (Bell; 1927), have shown just how successful this could be.

Dr. J. A. B. Gray (University College, London), who read a paper on "Physiology in Universities", also stressed the emancipation of physiology from its ancillary position in medicine. Physiology is the study of the mechanisms of living species and can be studied at different levels, in cells, in tissues, in organs, in systems and in individuals. It can be applied, not only to man in his life in a more or less normal community, but also to man at the summit of Everest and at the South Pole. It also extends over the widest limits of the comparative field from bacteria to man. He pointed to the growth of physiology as a subject in the faculty of science in one-year, two-year and honours courses. This field offers a unique opportunity for experiment and for the application of physics and chemistry to the fundamental processes of all living organisms. There is opportunity for a much fuller study of man in his place in the modern industrial and engineering world, in the design of instruments and machines to be operated by men and in the determination of the limiting factors in efficiency and endurance in new environments. Much closer links should be forged with psychology; philosophers, too, might profit from a course in physiology.

Thus while physiology must remain as an essential introduction to clinical medicine—the Institutes of Medicine—there are many reasons why ample provision should be made in every university for such courses in the faculty of science to meet other urgent needs.

Mr. H. P. Ramage (Gresham's School, Holt), dealing with "Physiology in Schools", spoke with obvious feeling and emphasis on the pressing need for a balanced education, not just as between science and the other subjects but within the field of science itself. Looking back to the findings of a Royal Commission of 1864 where the place of biology in schools was recognized, he pointed to the very small number of schools, and particularly boys' schools in Britain, where biology takes its proper place in the science curriculum. Biology is, he maintained, a necessary part of general science and general science a necessary part of general education. It is important to realize the value of biology for those who later would not go on to university, as well as for those who would. Much too strong an emphasis is being placed on the inorganic sciences in schools and this gives an unduly mechanistic bias to the minds of the young. Too few biology teachers are available in the schools. The Science Masters' Association is preparing a policy statement in the hope of restoring balance to the present lopsided presentation of science in schools.

Dr. W. Cobb (National Hospital, Queen Square, London), speaking on "Physiology in Medical Research", used the story of Berger's early pure research into changes in electrical potential on the human cerebral cortex, later confirmed by Adrian, to demonstrate how a piece of pure research may later have an extensive practical application. The original research was the patient, disinterested and long unappreciated work of an individual. It was, however, to become in the hands of many others the electroencephalograph, a routine procedure of diagnostic value, widely used in many cerebral conditions. Such an example of the later development of practical applications of pure research is one of many. Physiology will continue to discover new procedures which will later have quite unforeseen usefulness in other fields.

In neurology Dr. Cobb felt that too little work in cerebral physiology is being done in Britain. There is still a gulf, relatively unbridged, between the traditional clinical observational neurologist after the pattern of the great neurologists of the past, and the modern neurophysiologist trained in electronic techniques.

Dr. D. P. Cuthbertson (Rowett Research Institute. Aberdeen) read a paper entitled "Careers for the Physiologist in Agricultural Research". On the successful application of science to agriculture, which is the basic industry in Britain, Dr. Cuthbertson maintained, our future depends; and in this application, physiology has a foremost place. In agricultural research much has been done but much more remains to be done in the extension and orientation of physiological methods to urgent problems. As an example he described briefly the fascinating set of problems associated with digestion in the ruminants, where the problems of animal digestion are complicated by those of microbiology. He did indeed suggest that the physiologist who wishes to enter agricultural research should have a preliminary training in microbiology. He directed attention also to the need for extensive environmental studies, as for example the basic work being done at the Hannah Dairy Research Institute on temperature regulation in cattle. Another expanding area is that associated with the use of insecticides, where problems branch out into many other fields. There are other urgent questions pressing for solution, but where, asked Dr. Cuthbertson, are the physiologists?

Dr. J. Yule Bogue (Pharmaceuticals Division, Imperial Chemical Industries, Ltd.) spoke on "Physiologists in Industry".

Industry has to undertake research, some of it of a fundamental nature, in its efforts to further its own strictly practical aims, for example, the preparation of new pharmaceutical products. In a university post, the young physiologist has to combine research with teaching: in industry he or she has to link together research and routine testing. Just as good research in universities is associated with and indeed stimulates good teaching, so good research in industry is associated with good routine work and might indeed find in it interesting new problems. Physiologists in industry are faced with two groups of questions requiring solution. (*a*) Problems of environmental physiology, for example, in the determination of the conditions in industry which make for maximal efficiency: how man may best be protected from hazards of many kinds, or how the design of instruments may give the least possible fatigue, etc. In this group the medically qualified physiologist is essential. (*b*) Problems which emerge in the study of the action of new products and in the search for further products. These are largely dependent on comparative physiology and may range widely: a medical qualification is not required.

As a preparation for industrial work a wide general physiological experience is best; specialization can be provided in the industry itself when necessary. Dr. Bogue refuted the suggestion that the scientific staff may be under pressure from the management: rather it is a question of the research colleagues supplying the incentive. Generous provision is made in industry for the scientific staff to attend and take part in academic and scientific societies.

Reading a paper on "The Training of Physiologists", Prof. D. H. Smyth (University of Sheffield), who has had a lifelong interest in educational problems, began by speaking of the two different types of individual who might take up physiology as a career. One is the mathematically-minded person who, perhaps, shows his true bent in his hobby of taking the family car to pieces and putting it together again. The other is the biologically-minded individual whose leisure time has been for years expended in early nature studies and who later becomes the serious bird-watcher, fisher or amateur botanist, for he is essentially an outdoor type. While the biologically-minded type is better equipped to see the real physiological problem and has much more highly developed powers of observation, it is the mathematically-minded type who would in the end make a satisfactory analysis of the problem and offer an adequate mathematical solution. In direct contrast to Mr. Ramage, Prof. Smyth was inclined to question the value of biology as a subject in the school curriculum. It is unfortunate that the educationists are as a rule inclined to put their bright pupils into physics and chemistry and the less bright into biology. What is needed is a combination of a good mathematical training and a driving interest in living organisms and how they function. Without the essential motive the more mechanically minded may become just purveyors of gadgets.

In the general discussion that followed these short papers, a questioner was assured that up to the present no difficulty has been experienced in placing women graduates in physiology, and also that no discrimination against women with first-class honours degrees exists in industry.

Dr. Bogue stressed the fact that recently graduated candidates would only be accepted for research by Imperial Chemical Industries, Ltd., if they had first-class honours degrees. He made it clear, however, that many second-class honours graduates were used in the more routine technical work. In his experience industry had found it well worth while to give a first-class honours chemistry graduate as much as three years special training in physiology or pharmacology to get the individual they wished.

There appears to be little accurate knowledge available of the actual number of posts open to physiologists in Britain. In view, however, of the number of unfilled vacancies there seemed to be no likelihood of over-crowding within the next few years. Dr. Gray spoke of even third-class honours graduates having no difficulty in finding suitable work.

Prof. Gerard then spoke of his own interest in this question and in the survey made recently by a committee in the United States, and published under the title "Mirror to Physiology". He discussed the status of physiologists in America and the need for more physiologists there, and also for an improvement in the standards of the lower levels of physiology teaching.

Dr. R. H. Noltie directed attention to the development of physiology teaching in university and college departments of biology and zoology, in isolation from the traditional physiology departments.

The discussion closed with some telling remarks by Sir Charles Lovatt Evans. He reminded the meeting of the difference in rate of development which often means that the good second-class honours man eventually became the first-class researcher who makes the real advances in our knowledge. It was not always true that the first-class honours man became the first-class research worker. Sir Charles thought also that the present concern in many circles for technology and technicians is not without its dangers. Science is a way of thinking and technology is a way of doing things. In his view, there can be no doubt which is the more important.

Thus several points emerged which merit consideration at a future date: (1) The value of the teaching of biology in schools, including some elementary physiology, to all those who will not proceed later to university; (2) the place of biology beside chemistry and physics in the school programme for those who will eventually go to a university; (3) the integration of the teaching of physiology in colleges and universities where this is now being done outside the departments of physiology; (4) the need for a survey of the number of physiology graduates required each year not only in the traditional physiology college and university departments but also throughout the whole field, so that training may be geared to the numbers required and diversified to meet the various new demands.

H. S. D. Garven

SEMICONDUCTOR RESEARCH

In the ten years that have elapsed since the invention of the transistor, the close interaction between academic interest and industrial requirements in the semiconductor field has led to the growth of many industrial and government laboratories with interests in this subject. Because of the connexion with academic work, these laboratories were readily able to grow by attracting graduates of suitable calibre. This has naturally led to much research activity in the semiconductor field, and this is nowhere more pronounced than in the United States. There the transistor was invented, and there alone has it been marketed competitively. It was therefore appropriate that the bi-annual international conference on semiconductors should at last be convened in the United States, having previously met in Britain, Holland and Western Germany. The attractive and spacious campus of the University of Rochester was selected, and the meeting was held during August 18–22 under the chairmanship of John Bardeen. Almost all centres of semiconductor research were represented.

Even with the restrictions placed by the organizers on the number of papers read at the conference, their detailed discussion is not possible here. The general headings have not changed very much since the last meeting in 1956[1], but some changes of emphasis have occurred in the interim and will now be surveyed.

Excitons. There was considerable interest in excitons at the 1956 meeting[1], with particular reference to the pioneer work of E. F. Gross (Leningrad) and S. Nikitine (Strasbourg), who had noted exciton spectra. Their experiments, which were still questioned in 1956, have now been largely accepted.

and they both reported at Rochester on their work. In particular, Gross showed how the quadratic diamagnetic Zeeman effect, rather than the linear paramagnetic effect, was observed in the cuprous oxide exciton spectrum. This suggests that the excitons behave here like positronium atoms, with equal effective masses for electron and hole.

The propagation of photoconductivity in single crystals of cadmium sulphide over distances of millimetres had been attributed tentatively to the properties of excitons[1]. This surprising result was reported in 1956 in a paper by Balkanski and Broser: the latter author now favours a different explanation of the results, namely, the scattering and re-absorption of luminescent radiation. He described experiments which furnish good evidence for his present view. In other papers (T. Muto, Tokyo; B. Goodman, Missouri; W. Martienssen, Göttingen) the role of excitons in ionic crystals was also discussed.

Evidence for the creation of excitons in germanium and silicon has recently been obtained from the fine structure of the absorption edge. British work by G. G. Macfarlane and his colleagues at the Royal Radar Establishment, Malvern, as well as the theoretical interpretation by R. J. Elliott (Oxford) was given due prominence at the meeting. In the latter contribution, the new material included a discussion of the effect of the Coulomb interaction, previously neglected. Work at the Lincoln Laboratory (B. Lax *et al.*) has confirmed some of these results, and an exciton life-time of the order of 10^{-11} sec. has been suggested for germanium in zero field. Fine structure in the intrinsic recombination radiation (J. R. Haynes *et al.*, at the Bell Telephone Laboratories) is consistent with this optical absorption work. There is, therefore, now firm experimental evidence for the existence of excitons in both elemental and compound semiconductors. It is hoped to learn more from these experiments about the exciton spectra, and about the phonons which can take part in their excitation.

Optical and magneto-optical effects. There has also been considerable progress in this field since 1956. In a magnetic field the electron states in a band are displaced on an energy scale to give rise to the so-called Landau levels. Since the optical transitions into the conduction band depend on the density of final states, one would therefore expect oscillations if the absorption coefficient is plotted against photon energy. Such oscillations due to interband transitions have been found, notably in germanium, InSb and InAs (E. Burstein *et al.*, Philadelphia; B. Lax, Lincoln Laboratories), and progress has been made in the interpretation of the large amount of information now available.

Low-temperature optical absorption experiments, made with the view of finding evidence for the excitation and ionization of impurities, have been pursued by H. Y. Fan *et al.* (Purdue), at liquid-helium temperatures and out to 300μ, on various concentrations of impurities in silicon and germanium. A significant development here is that in recent years the simple hydrogen-like model for the impurities has been replaced in the interpretation of experiments of this kind by the more refined model of W. Kohn. Upon applying a magnetic field the Zeeman splitting of the excited states can be observed. In addition to the magneto-optical interband oscillations mentioned above, a similar effect must be expected if the electrons are initially in impurity states, and this has also been observed (R. F. Wallis, Washington; W. S. Boyle, Bell Telephone Laboratories).

Reviews of work on certain infra-red phosphors (G. F. J. Garlick, Hull) and of conductivity and luminescence of diamonds (E. W. J. Mitchell, Reading) were also given.

Recombination. So far as the theory is concerned, recent efforts in this field have been devoted to the investigation of more and more mechanisms with the view of explaining the experimental results, which are still poorly understood as regards absolute values, though the situation is better if one restricts attention merely to the explanation of shapes of curves. At the meeting, reasons for the large capture cross-sections ($\sim 10^{-14}$ cm.^{2}) of traps in germanium and silicon were put forward (M. Lax, Bell Telephone Laboratories), and the part played by the Auger process in recombination was discussed. The main weight of research, however, has been concentrated on accumulating more experimental information. The work on the effect of dislocations on recombination-rates should here be mentioned as an active field (A. F. Gibson, Royal Radar Establishment, Malvern; P. Baruch, Paris; R. K. Müller, Minneapolis; H. Kawamura, Tokyo). In particular, surprisingly detailed structure was reported in the recombination radiation through dislocation in germanium at 20° K. (C. Benoit à la Guillaume, Paris).

Perhaps the most interesting 'hard' results (because they are older and confirmed) to be discussed were those on deep-level impurities in germanium, where different experimental methods led to the same picture, namely, the possibility of multiple ionization of the impurities (W. W. Tyler, Schenectady). Though the statistics of recombination through such centres appears to be well understood, a satisfactory calculation of the position of the energy-levels is still outstanding.

Hot electrons, high-field effect and impact ionization. The term 'hot electrons' is due to Shockley (1951). (It is perhaps not generally known that the concept of effective electron temperatures in solid state physics appears to have been used first by H. Fröhlich[2].) The three concepts, hot electrons, high-field effect and impact ionization, are closely related, since a high electric field causes electron-hole pairs to be created by impact ionization—a conduction electron knocks an electron out of the valence band—and it also causes electrons to gain more energy than they can lose to the lattice, so that they can attain a temperature greater than that of the lattice. Among the main advances made since 1956 is the now widespread appreciation that one can realize, by impact ionization, quantum efficiencies in excess of unity. This is largely due to the work on the inner photoelectric effect by the Czech school (J. Tauc, Prague).

Another interesting effect is the evidence of anisotropy in electric conduction at high fields, which can have the effect that some valleys (of the energy surfaces in k-space) become hotter than others, with a consequent transfer of electrons from the hotter to the colder valleys (W. Sazaki *et al.*, Tokyo). Attention was also directed to the importance of electron–electron scattering with the resultant emission of optical phonons as a loss mechanism for hot electrons (J. B. Gunn, Vancouver). Interesting results, recently published in *Physical Review Letters*, on the use of pulsed current-voltage measurements to show the incidence of impact ionization in n-type single crystals of InSb were also presented (M. C. Steele and M. Glicksman, Princeton).

Other transport effects. In this field a large amount of detail has been filled in, and some was reported at the meeting, on both the older and the newer semiconductors. The main Russian contribution may be mentioned here, namely, to direct attention again to the low-mobility semiconductors (A. Joffé, Leningrad), which may raise fundamental problems. For example, if the mean free path of electrons is of the order of: $l = 10^{-8} \sqrt{(m_e/m)}v$ cm., where v is the mobility and m_e the effective mass of electrons, then l is less than atomic distances for $v < 10$ cm.^{2}/volt-sec., and therefore ceases to have a meaning. The concept of energy-bands itself may become inapplicable. Impurity scattering and mobility theory would both require extensions for this class of substances. The view was also expressed that the change of electrical properties during melting suggests that the zone structure of solids depends only on short-range order. Great difficulties, however, stand in the way of understanding disordered structures, to which a paper by C. Domb *et al.* (London) was devoted.

Substances which exhibit impurity-band conduction present some features of a disordered low-mobility system, but little progress in the understanding of this phenomenon appears to have been made, though interesting papers on this topic were presented at the meeting (germanium, H. Fritsche, Chicago; silicon, T. Longo *et al.*, Purdue; InSb, R. J. Sladek, Pittsburgh).

Low-temperature photoconductivity in silver halides was described by J. W. Mitchell (Bristol) and F. C. Brown (Urbana).

Bonds. In connexion with the renewed attempt to look beyond the band picture, a number of substances have been studied recently the properties of which may possibly be more readily understood in terms of some chemical-bond picture. A curiosity among these is the compound AuCs, with two elements of the first group, which is a large-gap ($E_g \simeq 2 \cdot 9$ eV.) semiconductor (W. E. Spicer and A. H. Sommer, Princeton). Also of interest are the $A^{III} B^{VI}$ compounds from the third and sixth group (for example, GaTe), which have been investigated by E. Mooser *et al.* (Ottawa). These are semiconductors although they have nine valence electrons per anion, that is, one more than is normal in such semiconductors.

Bands. There was at the 1956 meeting an almost complete absence of energy-band calculations[1], but this was not true of the 1958 meeting. Several American workers have recently reconsidered the status of the one-electron approximation, and W. Kohn (Pittsburgh) spoke on the justification of the one-electron effective-mass approximation from the many-electron Schrödinger equation. The effect of a magnetic field may require further consideration here. The use of potential operators in band calculations was also discussed. Particularly the $\mathbf{k} \cdot \mathbf{p}$ approach (E. O. Kane, Schenectady) has in recent years proved very useful, though it was suggested by J. C. Philips (Bell Telephone Laboratories) that rather large corrections may be required. Band forms discussed at the meeting included ZnS (J. L. Birman, Bayside), InAs (F. Stern, Silver Springs), GaAs (R. Braunstein, Princeton), apart from silicon and germanium.

Surfaces. There has been steady consolidation in this field, which was surveyed by A. Many (Jerusalem). The distinction between fast and slow states appears to remain useful, and the origin of the fast states is still not understood, though they are believed to reside in the transition region from the bulk material to the surface oxide. The time-lag which usually exists before experiments on the bulk material are attempted for a restricted part of the surface layer is, however, shortening, and optical, magnetic and transport properties of surfaces were discussed (for example, by J. N. Zemel and R. L. Petritz, Silver Springs). The adsorption on germanium and silicon appears to follow a logarithmic rate law (S. Wolsky, Waltham), familiar in oxidation and chemisorption studies. Reproducible 'clean' ('Farnworth') surfaces can be produced by ion-bombardment or heating techniques, and these have now become standard procedures.

The meeting closed with a very useful summary session, in which L. Apker, W. H. Brattain, H. Brooks, C. Herring and D. Polder took part, and one may express the hope that this will become an increasingly important pattern of future meetings. The proceedings will be published early in 1959 in the *Journal of the Physics and Chemistry of Solids*, and the next meeting will probably take place in Prague in 1960.

P. T. LANDSBERG

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[1] *Nature*, **178**, 1156 (1956).

[2] *Proc. Roy. Soc.*, A, **188**, 521 (1947).

THE EUROPEAN NUCLEAR ENERGY AGENCY

UNDER the title "The European Nuclear Energy Agency and the Eurochemic Company*, the Organization for European Economic Co-operation has published the first report of its Steering Committee for Nuclear Energy. It includes the Statute for the European Nuclear Agency, which the Committee recommends the Council should adopt, as well as two draft conventions, one on the establishment of security control in the field of nuclear energy and the other on the constitution of the European Company for the Chemical Processing of Irradiated Fuels (Eurochemic). The former is to be recommended to member governments for signature and the latter is to be submitted for signature to the governments interested. Amendments to its Statute are also proposed by the Study Group for the Chemical Processing of Irradiated Fuels and authorization is requested for expenditure by the Study Group of 500,000 European Payments Union units of account. The Study Group also recommends that the proposed plant should be located at Mol in Belgium, but if it were decided later to construct a large plant the most suitable site is considered to be that proposed by Norway. The present plant is estimated to cost

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* Organisation for European Economic Co-operation. European Nuclear Energy Agency and the Eurochemic Company. First Report of the Steering Committee for Nuclear Energy to the O.E.E.C. Council. Pp. 192. (Paris: Organisation for European Economic Co-operation, 1958.) 750 French francs; 12*s.*; 2 dollars.

12 million E.P.U. units of account and, including research, would require a staff not exceeding 400–450.

The Steering Committee expects shortly to submit proposals for the joint construction or operation of two experimental reactor projects (boiling water reactor and homogeneous aqueous reactor) and is also to report shortly on the measures at present under discussion for liberalization of international trade. It is also to submit proposals regarding training, and particularly the assistance to be given to universities and higher technical colleges of member countries for training specialists; health and safety, particularly the examination of projects for the discharge of radioactive waste, the evaluation of reactor hazards, and the international transport of highly radioactive materials; and liability and transport, particularly the drawing up of common rules concerning third-party liability in the nuclear field. Annexes to the report include a general description of the recommended processing plant, the text of the proposed conventions and the amended Statute of the Study Group, as well as the proposals of the working groups on experimental reactors and on nuclear power stations for their co-operative development in Europe. There is also a summary of the national programmes for building nuclear power stations in Austria, Belgium, France, Western Germany, Italy, the Netherlands, Sweden, Switzerland and the United Kingdom.

On the basis of this report, the Council, on December 17, 1957, adopted the Statute of the European Nuclear Energy Agency, and the International Convention on Security Control was signed by member countries of the Organization for European Economic Co-operation on December 20. The text of this Statute and the Convention (see *Nature*, 181, 952; 1958) are also appended to the report, which, with the details of membership of the study groups, working groups and working parties and of the Steering Committee itself, is a particularly useful reference document on the present development of nuclear energy in Europe.

THE TASMANIAN MUTTON-BIRD

THE Tasmanian mutton-bird, *Puffinus tenuirostris* (Temminck), is known to ornithologists as the short-tailed or slender-billed shearwater, and was known to the Tasmanian aborigines as 'yolla' and to the white seafarers of Bass Strait as the 'yowler'. Historically it is recorded earlier than white settlement of Australia; sociologically it has importance as the only example of commercial wildfowling successfully surviving in Australia and in being the mainstay of that interesting community, the Cape Barren Islanders; scientifically, it amazes naturalists through the astonishing regularity of its breeding time-table, its widespread migration and its uncannily accurate homing each year to its exact nesting site. It also occurs in such abundance that it could quite well be Australia's most numerous bird. An interesting account of the bird has been prepared by D. L. Serventy*.

Puffinus tenuirostris is a long-lived bird, and, for its size, has an unusually lengthy period of sexual immaturity. Female birds begin to breed at 5–7 years of age and males at 7–8 years. Immature birds do not make a landfall, once they leave their natal islands as fledglings, until they are 3–4 years of age.

The sexually mature, breeding birds return from their migration to the nesting islands in the last week of September, and by then gametogenesis is well advanced. Burrows are actively scratched out, and vocal performances enliven the rookeries at night. Though egg-laying does not begin until the third week in November, a striking behavioural change occurs at the beginning of November. The birds vacate the islands entirely, and do not return again until the onset of egg-laying.

The exodus follows immediately after fertilization, and the birds leave for the open sea while the single very large egg matures (it weighs about 85 gm. and is about 16 per cent of the female's body-weight). Though this pre-egg-laying exodus was known in the Tasmanian mutton-bird from early times, it was not detected in other petrels until comparatively lately.

Egg-laying starts about November 20–22 and ends about November 30–December 2. The calendar is invariable from year to year and from rookery to rookery, though these are spread through eleven degrees of latitude—from near Ceduna, in South Australia, to southern Tasmania—adjacent to seas which differ widely in temperature, chemical composition and currents. Year-to-year variations in the local sea conditions, or the weather, have no influence on the breeding calendar, which is the same now as when the earliest observers wrote their accounts more than a hundred years ago. This surprising constancy has yet to be fully explained.

When the birds return to their nesting islands for the egg-laying the male gonad has dwindled drastically in size, and the seminiferous tubules are in a state of fatty metamorphosis. No other avian species shows a more rapid collapse of the testis, though this may be characteristic of the petrel group. When the egg is laid, the female departs to the sea to recuperate.

The newly hatched chick is rarely tended continuously by the parents for longer than two days and is then left alone by day. Both parents share in the feeding, which takes place at intervals, and the young bird may have to undergo lengthy fasts of several days between Gargantuan banquets of krill. The growth-rate is rapid and the fledgling may come to exceed the weight of a large adult in little more than a month after hatching. The young birds emerge from the burrows at night, vigorously exercise their wings and at length make their own departure from the natal islands. This exodus of the fledglings usually occurs from the third week in April to the first week in May.

The nature of this migration has long been a matter of speculation. Some ornithologists were loath to believe that the birds in the northern Pacific could be of the same breeding stock as the Australian birds. The first ornithologist to suggest that the north Pacific birds were Australian birds on migration was A. J. Campbell. It was only in 1955 that the first positive proof was obtained by a banding record.

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* *Aust. Mus. Mag.*, 12, No. 10 (June 15, 1958).

The route followed on migration appears to be largely conditioned by the direction and strength of the prevailing winds. By flying a roundabout 'figure of eight' course over the Pacific the birds are assisted by wind. The only place where they meet with any strong wind resistance is on the southward leg of the route when returning to Australia in the spring. Here they have to battle against the strong south-east trade winds which blow all the year round across the Pacific. Wherever they cross this belt the birds encounter strong winds.

These youthful first- and second-year birds share in the general migration of the more mature birds, though some individuals among them may continue to spend the southern summer in the north. Such behaviour is not unusual with other trans-equatorial migrants, such as the waders. Even though they may migrate south with the breeding birds, the first- and second-year individuals do not come ashore but remain at sea. It is only when they reach three years of age that they effect a landfall, and then only comparatively briefly, between hatching time in January and the third week in March. The fourth-year birds show a similar behaviour, but more appear to come ashore at this age than at three years, and some individuals even put in an appearance earlier in the season, namely, from mid-December onwards. When they are five years and older the birds appear to come ashore with the breeding adults, though they remain unmated.

Once a bird begins to breed on a particular site, it tends to return to the same spot each season with remarkable fidelity. Often it remains mated with the same partner. On Fisher Island there are several examples of birds which have bred together each year since observations first began in 1947.

AN ANTIBONDING MORSE POTENTIAL

By ROBERT W. KEYES

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MORSE has proposed a three-parameter function,

$$\mu(r) = L[\exp\{-2\beta(r-a)\} - 2\exp\{-\beta(r-a)\}] \quad (1)$$

to represent the potential function for the motion of the nuclei of a diatomic molecule[1]. The function (1) has proved quite useful in the understanding of the properties of diatomic molecules, since Morse was able to solve the one-dimensional Schrödinger equation for motion in the potential $\mu(r)$, and thus to express the molecular energy-levels in terms of the parameters L, β and a.

I wish to suggest how the potential for the antibonding state corresponding to (1) can be represented by a similar function. Compare function (1) with a one-electron system in which the quantum mechanical theory easily leads to an approximate analytical formula for the potential for nuclear motion, namely, the hydrogen molecule ion. In the approximation in which the wave function is considered to be a linear combination of atomic 1*s* functions and the Coulombic field of the second nucleus is considered as a perturbation, the potential in question is:

$$\mu(r) = \mathrm{f}(r)\exp(-2r/b) - \mathrm{g}(r)\exp(-r/b) \quad (2)$$

where $\mathrm{f}(r)$ and $\mathrm{g}(r)$ are algebraic functions of r, the distance between the two protons, and b is the Bohr radius[2].

Now, in (2) we assume that the important dependence on r arises from the variation of the exponentials, rather than of the algebraic functions. That is, we make the approximations $\mathrm{f}(r) = f_0$ and $\mathrm{g}(r) = g_0$, where f_0 and g_0 are constants. It is then found that the minimum of the potential (2) occurs at $r = c = b \log(2f_0/g_0)$, and that (2) can be written:

$$\mu(r) = f_0 \exp(-2c)\,[\exp\{-2(r-c)/b\} - 2\exp\{-(r-c)/b\}] \quad (3)$$

But (3) is the same as (1) with $\mathrm{L} = f_0 \exp(-2c)$, $\beta = 1/b$, and $a = c$.

Thus, it is seen that the first and second terms of the Morse potential (1) correspond to the first and second terms of (2), respectively. The theory[2], however, reveals the physical origin of the terms of (2). The first term arises from Coulombic interactions of the protons and electron, and is always repulsive. The second term arises from the resonance or exchange integral, and, for the state in question, is attractive. Thus, we identify the first and second terms of the Morse potential with the Coulombic and exchange effects, respectively.

The usefulness of this interpretation arises from the fact that the potential function for the antibonding electronic state of the hydrogen molecule ion differs from the bonding state only in the sign of the exchange integral, except for an orthogonality correction[2]. Thus we would expect that the potential for the antibonding electronic state arising from the atomic functions which give rise to (1) can be approximately written as:

$$\mu_{ab}(r) = L[\exp\{-2\beta(r-b)\} + 2\exp\{-\beta(r-b)\}] \quad (4)$$

The validity of the approximations involved in the use of (4) to represent the antibonding potential is checked in Fig. 1, where the bonding and antibonding potentials given by the simple perturbation theory for orbitals composed of linear combinations of atomic 1*s* functions for the hydrogen molecule ion are plotted as solid lines. A Morse function (1) can be chosen to give a quite good fit to the bonding potential. The fact that the algebraic functions $\mathrm{f}(r)$ and $\mathrm{g}(r)$ have been replaced by constants shows up in that the value of β which gives the best fit of (1) to (2) is not exactly $1/b$. According to (4), the antibonding potential corresponding to (1) can be obtained by simply changing the sign of the second term of (1). This antibonding potential is also plotted in Fig. 1 as a dashed line, and is seen to be a good approximation to the result of the perturbation theory.

In a system in which many electrons contribute to the bond between two atoms, in general the contribution of some of the electrons to the bonding potential will be bonding and the contribution of

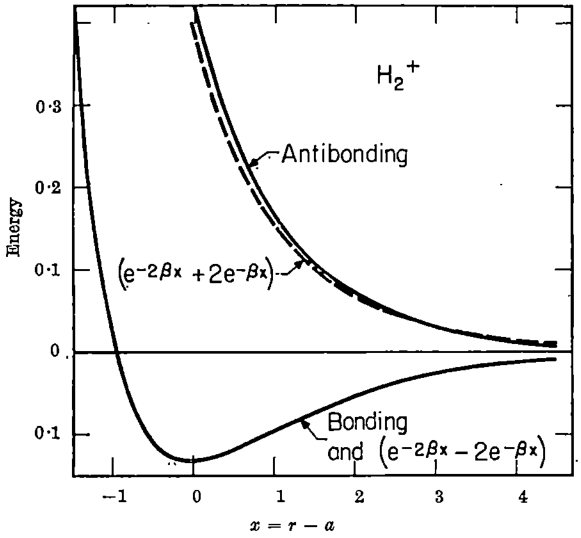

Fig. 1. The solid curves represent the nuclear potentials for the bonding and antibonding electronic states of the hydrogen molecule ion. The dashed curve is obtained by fitting a Morse function to the bonding potential and reversing the sign of the second term

other electrons to the potential will be antibonding. Thus, if it is assumed, (1), that the total potential, $V(r)$, can be constructed by addition of contributions from individual electrons, and (2) that the parameters L, a and β are the same for all electrons involved in a particular bond, then $V(r)$ is a linear combination of the potentials $\mu(r)$, equation (1), and $\mu_{ab}(r)$, equation (4). It is easily seen that these linear combinations are also potentials of the Morse form.

If the total number of electrons which contribute to $V(r)$ is constant, all such linear combinations form a one-parameter family of Morse functions. Some members of one of these families are plotted in Fig. 2. An extensive analysis of the properties of such families of Morse functions will be described in a separate communication[3]. The particular result of the analysis which will be used here is that the parameter β is the same for all members of a family and that the vibrational frequencies, ω_e' and ω_e'', associated with two members of a family are related to the nuclear separations at the potential minima, r_e' and r_e'', by:

$$\frac{\omega_e'}{\omega_e''} = \frac{\exp(-\beta r_e')}{\exp(-\beta r_e'')} \qquad (5)$$

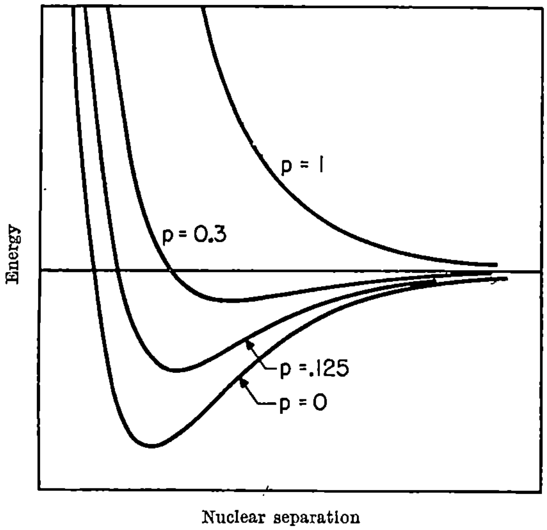

Fig. 2. Some members of a one-parameter family of Morse potentials of the type described in the text. The parameter p is the fractional amount of antibonding potential in the total potential, namely, $V(r) = p\mu_{ab}(r) + (1-p)\mu(r)$

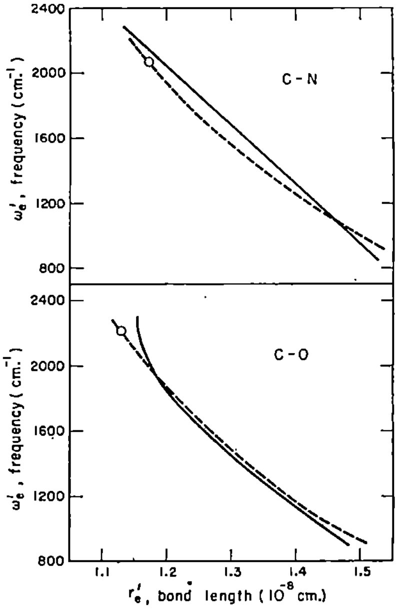

Fig. 3. Comparison of empirical frequency versus bond-length curves, the solid lines (ref. 4), with those calculated according to equation (5), the dashed lines, from the properties of the ground-state of the corresponding diatomic molecules. These ground-states are indicated by the points on the curves

To use the concepts introduced here, we assume that various states of a particular molecular bond all involve the same number of electrons, and differ only in their distribution of electrons between bonding and antibonding states. Then equation (5) represents a correlation between the vibrational frequencies and internuclear separations of the states of the bond. It will be shown elsewhere that the present model gives a reasonable account of the relations between the properties of some familiar diatomic molecules in various states of excitation[3]. Here we may compare equation (5) with the empirical frequency versus bond-length curves recently given by Layton, Kross and Fassel[4] for the C—N and C—O bonds in polyatomic molecules.

To make this comparison we have evaluated the parameter β for the C—O and C—N bonds from the anharmonicities of the ground-states of the respective diatomic molecules, and have used for ω_e'' and r_e'' the values observed for these states[5]. The curves ω_e' versus r_e' which are then found from equation (5) are plotted in Fig. 3, together with the curves given by Layton *et al.* It is seen that in both cases the correspondence of our calculated curve with the empirical one is quite close.

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MODE OF ACTION OF INTERFERON

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INTERFERON is the name that was given to a substance produced by the interaction of inactivated influenza virus with cells[1]. Interferon inhibits the growth of a variety of viruses and it seems to be the mediator of the phenomenon of virus interference. Its antiviral action, which includes ribonucleic acid viruses like those of the influenza group and deoxyribonucleic acid viruses like those of the pox group, seems to be directed at some early stage in the virus multiplication cycle within cells.

It was found earlier that when heated (56° C.) influenza virus was incubated with chick chorio-allantoic membranes *in vitro*, interferon was formed for a period of about 24 hr. only; but a second inoculation of heated virus then produced a second 'crop' of interferon[2]. This finding led to an investigation of other stimuli which might produce a second crop of interferon. It was observed that, in general, only virus capable of inducing production of interferon in untreated cells had the same effect in cells previously incubated with heated influenza virus. But one exception was found: live influenza virus, which does not normally produce interferon during the course of its multiplication in normal chorio-allantoic membranes, did so when incubated with membranes in which interference had been induced by previous incubation with heated influenza virus[3]. Since interference seems to be mediated through interferon, which is itself incapable of reproduction, it was of interest to see whether live virus would produce interferon in cells previously treated with interferon.

The experiment was carried out as follows. Three sets of chorio-allantoic membranes were used—one experimental and two control. Sufficient interferon to produce about 95 per cent interference with the growth of influenza virus was added to two sets of membranes, and Earle's buffered salt solution to the third. The membranes were incubated at 35° C. in bottles in a shaking machine delivering 86 strokes a minute with an amplitude of 1 in. After 3 hr., the membranes were removed, washed thoroughly and incubated overnight in buffer. Next day the membranes were incubated in the same way, but two sets with live influenza virus (strains *MEL* or *PR*8) and the third with buffer; the amount of influenza virus used corresponded to an estimated multiplicity of about one *ID*50 per cell. After 3 hr. the membranes were again washed and incubated overnight with buffer. The fluids were removed, and titrated for hæmagglutinin, in order to demonstrate satisfactory growth of influenza virus in control membranes, and inhibition of virus growth in membranes pre-treated with interferon. The fluids were next dialysed overnight against buffer at *p*H 2 (a procedure which inactivates virus but leaves interferon unaffected), then dialysed back to *p*H 7 and centrifuged to remove precipitates before testing for interferon content.

The fluids from the second 24-hr. period were tested for their ability to inhibit the growth of influenza virus in small pieces of chorio-allantoic membrane *in vitro*[1]. At the same time, the fluids from the first 24-hr. incubation period were usually tested for control purposes and they invariably showed no interferon. The results of one experiment of this kind are shown in Table 1, where the interferon content of the fluids is expressed as the amount of inhibition ($\log_2$) of virus growth produced in the test system.

Table 1. PRODUCTION OF INTERFERON BY LIVE VIRUS IN CELLS PREVIOUSLY TREATED WITH INTERFERON

First inoculum	Second inoculum	Yield of interferon* ($\log_2$)
Interferon	Buffer	0·2
Buffer	Live influenza virus	1·1
Interferon	Live influenza virus	5·7

* Expressed as the amount of inhibition ($\log_2$) of virus growth produced in the test system. An inhibition of $\log_2 = 2$ is significant at the 1 per cent level (ref. 1).

It is seen that treatment of chorio-allantoic membranes with interferon followed by buffer did not produce interferon in significant amount, nor did growth of virus in previously untreated membranes. But in membranes pre-treated with interferon a highly significant amount of interferon was produced.

This type of experiment can now be reproduced regularly; but difficulties were encountered at first. In one group of experiments with a particular batch of interferon, the interferon appeared to be reproducing itself; this was traced to the fact that this batch contained a small amount of live influenza virus resulting from the use of incompletely inactivated virus in the production of this batch of interferon. When the interferon was incubated with chorio-allantoic membranes, some multiplication of the virus presumably occurred before interference was established, and this virus was then able to induce further production of interferon in the membranes which had adsorbed interferon earlier. In order to avoid this difficulty in later experiments, each batch of interferon was treated at *p*H 2 to destroy any live virus. Another point was that an adequate amount of interferon was required for the priming dose, as it was found that the greater the priming dose of interferon the greater the yield following incubation with live virus. It was also found necessary to use a dose of live virus sufficient to infect all cells in the first cycle; when fewer cells were infected a smaller yield of interferon resulted within the period of incubation. One final difficulty was that some batches of live virus produced interferon in untreated membranes. The reason for this may have been the use of old virus seeds in which interferon apparently accumulates. This requires further investigation, but from the point of view of the present experiments the difficulty was avoided by using fresh 24-hr. harvests of virus.

These experimental difficulties, once resolved, tended to confirm the fact that live virus produced interferon in cells previously treated with interferon. This might be explained by assuming that interferon

Table 2. EFFECT OF HEAT ON THE ABILITY OF ULTRA-VIOLET IRRADIATED INFLUENZA VIRUS TO PRODUCE INTERFERON IN UNTREATED AND INTERFERON-TREATED CELLS

First inoculum	Second inoculum	Yield of interferon ($\log_2$)
Buffer	Ultra-violet inactivated influenza virus	2·9
Interferon	Ultra-violet inactivated influenza virus	4·1
Buffer	Ultra-violet inactivated virus heated 1 hr. at 60° C.	0
Interferon	Ultra-violet inactivated virus heated 1 hr. at 60° C.	0

was taken up by the cells, from which it could later be released by live virus. But ground extracts of the chorio-allantoic membrane prepared 24 or 48 hr. after inoculation of a large dose of interferon showed a negligible content of interferon. It seems more likely, therefore, that the live virus induced synthesis of interferon. This is supported by the experiment summarized in Table 2. In this experiment the technique was the same as in the experiment shown in Table 1.

The results show that when irradiated virus is heated to destroy its ability to produce interferon in untreated membranes, it loses its ability to do so in interferon-treated membranes.

These experiments suggest that cells treated with interferon and afterwards infected with live virus produce interferon instead of live virus. Interferon appears to be a protein, and it may therefore be an analogue of a protein normally formed during virus synthesis. If so, the mode of action of interferon could be described as deflecting virus synthesis from the production of a normal protein intermediate towards the production of interferon, which represents a 'blind alley' in virus production. Virus interference would then result from the same re-direction of the virus synthetic pathway.

With regard to the possible functions of the protein in virus multiplication, some recent work on phage may be relevant. Burton[4] has described experiments which show that early during phage growth, synthesis of phage deoxyribonucleic acid is preceded by synthesis of protein that is not a precursor of phage protein; and Stent[5] has produced evidence which leads him to suggest that at the onset of phage infection, phage deoxyribonucleic acid may transfer its information to a newly synthesized protein. If an animal virus replicates by transferring the information in its ribonucleic acid to a newly synthesized protein, then interferon could be an analogue of that protein. We might describe these results in the following terms: viral ribonucleic acid supplies both the pattern and the stimulus for replication, the pattern being mediated through the production of a protein. Interferon supplies only the pattern for replication. In the present experiments, viral ribonucleic acid infecting interferon-treated cells would find the pattern for replication already established by interferon, and the viral ribonucleic acid would then supply only the stimulus to replicate.

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DEGRADATION OF DL-METHIONINE BY RADIATION

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IN our previous communication[1,2] the degradation of DL-methionine by X- and β-rays was studied chromatographically with special regard to the degradation products containing sulphur-35.

In experiments reported here the quantitative relations between the irradiation dose, the amount of ammonia liberated and the decrease of methionine were determined. The ninhydrin-positive degradation products of methionine, as well as of methionine sulphoxide, sulphone and sulphoximine, have now been identified.

The experimental procedure employed here was essentially the same as previously described[1,2]. The irradiation intensities were determined with a ferrous/ferric[3] and with a benzene[4] dosimeter and amounted to 2×10^{18} eV./ml./min. Volumes of 1–1·5 ml. were irradiated under standard conditions in methacrylate or paraffin Conway vessels closed by aluminium foil. Doses of $0{\cdot}2$–4×10^{20} eV./ml. of X-rays and $5{\cdot}7 \times 10^{20}$ eV./ml. of γ-rays were used.

Ammonia was determined quantitatively by Conway's method. The decrease of methionine was determined by photometric evaluation of the chromatograms[5]. After chromatographically pure methionine-^{35}S had been added to the solution to be irra-

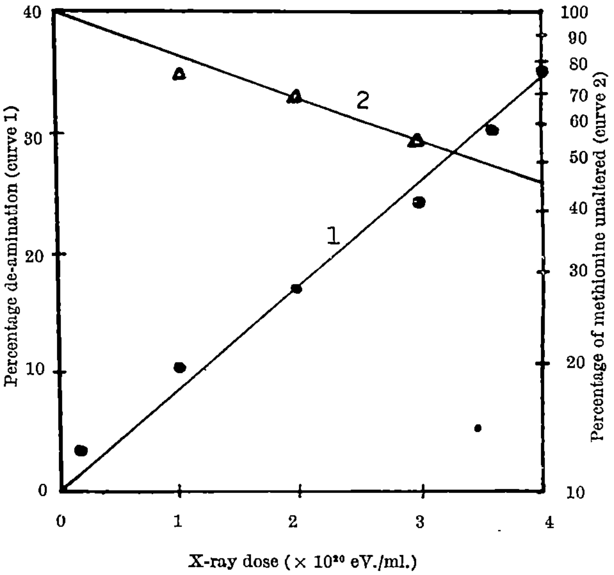

Fig. 1. Relation of the degree of de-amination and the decrease of methionine to the irradiation dose

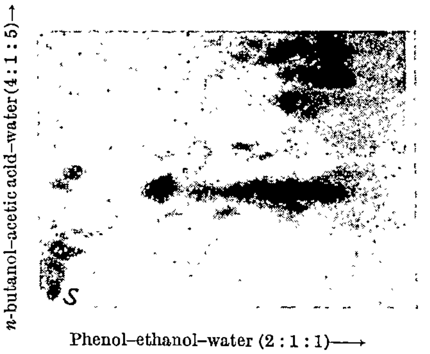

Fig. 2. Autoradiogram of the two-dimensional chromatogram of a methionine-^{35}S solution 90 days old. *S*, start

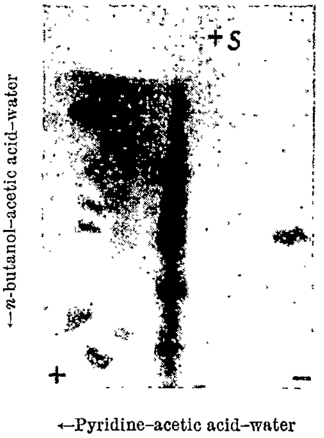

Fig. 3. Autoradiogram of the combined electrophoreto-chromatogram of methionine-^{35}S. *p*H 5·6. *S*, start

diated, the methionine content was determined radiometrically. The irradiated solutions were chromatographed, the spots of methionine-^{35}S were cut out, oxidized by a mixture of cupric nitrate and perchloric acid, the sulphate formed was dissolved in hydrochloric acid and precipitated as barium sulphate and its radioactivity determined. Chromatography, electrophoresis and autoradiography were performed as previously described[1,2]. The degradation products were identified by chromatographic comparison with standard compounds. α-Aminobutyric acid was identified by infra-red spectrography. The amount of sulphate in the irradiated solutions to which tracer quantities of methionine-^{35}S had been added was determined by precipitation as barium sulphate and radioactivity measurement.

The relation of the degree of de-amination and the decrease of methionine to the irradiation dose are given in Fig. 1. It can be seen that the degree of de-amination is a linear function of the irradiation dose, whereas the decrease of methionine content is an exponential function. The amounts of sulphur oxidized to sulphate were 0·21, 2·1 and 8·2 per cent for doses of 0·2, 2 and 3·6 × 10^{20} eV./ml. respectively. The amount of volatile compounds containing sulphur-35 (mainly CH_3SH) increased during irradiation; it amounted to 1·4 per cent of the total radioactivity at a dose of 2 × 10^{20} eV./ml. and 2·5 per cent at 3·6 × 10^{20} eV./ml.

After the irradiation of a DL-methionine solution with a dose of 3·6 × 10^{20} eV./ml. the following compounds were identified on a two-dimensional chromatogram: α-aminobutyric acid, threonine, alanine, aspartic acid, serine (in order of decreasing intensity of the spots). The decarboxylated products mentioned by Sahasrabudhe *et al.*[6] were not studied in detail. Their basic character was ascertained by paper electrophoresis. Methionine sulphoxide, meth-

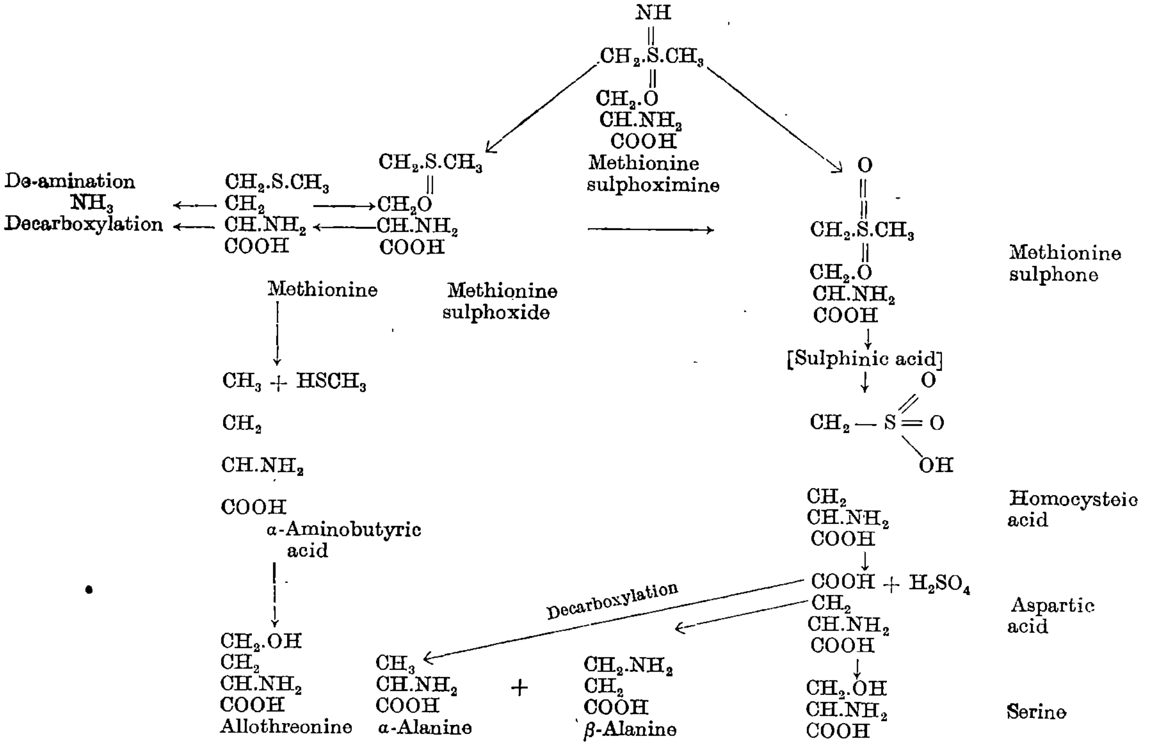

Fig. 4. Reaction pattern of the radiation decomposition of methionine-^{35}S (ninhydrin-positive compounds)

ionine sulphone and homocysteic acid, previously[1,2] identified as methionine radiation degradation compounds, were also detected.

Similarly, on the two-dimensional chromatogram of methionine-^{35}S (Fig. 2) 6 ninhydrin-positive and radioactive substances, 5 ninhydrin-positive only and 22 radioactive only compounds were found. The radioactive only compounds were predominantly acidic, as was ascertained by electrophoresis combined with chromatography and autoradiography (Fig. 3). These compounds are among the products of the de-amination process.

Irradiation of methionine sulphoxide with an identical dose under standard conditions gave the same compounds on the two-dimensional chromatogram as methionine, but they were in a different quantitative ratio ; the intensities of the spots due to homocysteic acid and aspartic acid especially were greater than those from methionine. When methionine sulphone was irradiated in the same way only spots of aspartic acid, homocysteic acid and serine were found.

On the basis of the comparison of the chromatographic picture of the irradiated solutions of methionine, methionine sulphoxide, methionine sulphone and methionine sulphoximine it is possible to summarize the reactions occurring during the decomposition of methionine by radiation (Fig. 4).

When solutions of methionine and methionine sulphoxide are irradiated with the maximum dose of X-rays, all the compounds in Fig. 4 are formed, but from methionine sulphone only homocysteic acid, aspartic acid, serine and alanine are formed. This degradation pattern can be explained by assuming that the reaction methionine $\rightleftharpoons$ methionine sulphoxide is reversible under the experimental conditions, but that methionine sulphone undergoes oxidative degradation only (Fig. 4). In this connexion it is of interest that methionine sulphoximine and methionine sulphoxide are degraded in similar ways. Obviously one of the first irradiation reactions of methionine sulphoximine is the splitting off of the NH-group. The further degradation products are not given in Fig. 4.

The investigation of the de-amination and decarboxylation processes will be the subject of further studies.

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INHIBITION AND EXCITATION DUE TO GAMMA-AMINOBUTYRIC ACID IN THE CENTRAL NERVOUS SYSTEM

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In 1954, Florey reported the presence in the mammalian brain and spinal cord of a factor, Factor I, which inhibits the generation of impulses by stretch receptor neurones of the crayfish[1], and in 1956 Elliott and Florey[2] purified the factor and identified it as γ-aminobutyric acid. In 1956, I suggested that β-hydroxy-γ-aminobutyric acid was the chemical transmitter of inhibition in the mammalian brain[3,4]. In 1957, McLennan showed that both these substances had an inhibitory action in nervous tissue[5].

The presence of γ-aminobutyric acid in the brain was discovered in 1950 by several workers[6,7], but the presence of β-hydroxy-γ-aminobutyric acid has not yet been conclusively demonstrated (my proof was indirect[8]) and most workers believe that γ-aminobutyric acid is the real inhibitory principle in the brain. However, I believe that stress should be laid on the importance of β-hydroxy-γ-aminobutyric acid for the following two reasons.

(1) It has a stronger inhibitory action than γ-aminobutyric acid on cerebral activity, for example, on the generalized seizure following electrical stimulation of the motor cortex in dogs. Most workers have experimented with stretch receptors and the spinal reflex and central electrical activity of lower animals[1,2,5], not on the activity of higher animals.

(2) In contrast to γ-amino-β-hydroxybutyric acid, γ-aminobutyric acid had an inhibitory as well as an excitatory action in some conditions.

The present results suggest that γ-aminobutyric acid is the precursor of both β-hydroxy-γ-aminobutyric acid and the substance causing excitation, of which the chemical constitution is not yet clear, but it appears to be a methylated derivative of γ-aminobutyric acid.

When electrical stimulation was applied to the motor cortex of the exposed brain of dogs, the generalized seizure appeared and continued for 60–180 sec. If, after the beginning of the seizure, a small dose of β-hydroxy-γ-aminobutyric acid or γ-aminobutyric acid, at an appropriate concentration, was rapidly introduced into the carotid artery, the seizure was abolished within 5–15 sec. If either substance was introduced into the cerebrospinal space, the seizure was abolished within 15–25 sec. Presumably these substances rapidly cross the blood-brain barrier and cerebrospinal fluid-brain barrier. It was confirmed that when isotonic saline solution, Ringer's solution or cerebrospinal fluid from other dogs was introduced in amounts up to 10–15 ml. no motor effect occurred.

When metrazole and sodium glutamate were introduced into the ventricle of dogs, they produced generalized seizure (Table 1). The latent periods did not exceed 15–20 sec. In contrast, *iso*nicotinic acid hydrazide and toxopyrimidine[9] had a latent period 30–200 times longer. To our surprise, vitamin B$_1$ and folic acid both produced the seizure and belonged to the group with the longer latent period.

Table 1. LATENT PERIODS TO PRODUCE SEIZURE VIA CEREBROSPINAL FLUID IN DOGS. 1 ML. SOLUTION WAS USED IN EACH CASE

Substance	Concentration (per cent)	Seizure	Latent period (sec.)
Metrazole	1·0	+	10–20
Sodium glutamate	10·0	+	15–20
*iso*Nicotinic acid hydrazide	20·0	+	2,000–2,400
Toxopyrimidine	10·0	+	600–1,200
Vitamin B_1	8·0	+	420–1,800
Folic acid	0·2	+	600–1,200

The most obvious interpretation of these results is that the convulsants with shorter latent periods act directly, by virtue of their chemical structure, and that the convulsants with the longer latent periods act indirectly. For example, they could undergo metabolic transformation during this longer period. Alternatively, it is possible that these compounds accelerate the production of the immediate excitatory mediator, or inhibit the production of compounds antagonistic to the natural mediator. In any event, the convulsants of the second group do not appear to be active *per se*. From these considerations, toxopyrimidine and *iso*nicotinic acid hydrazide are both antagonists of vitamin B_6, the coenzyme of glutamic decarboxylase. There have been many reports of the occurrence of seizure in animals suffering from vitamin B_6 deficiency. This can be interpreted as the result of β-hydroxy-γ-aminobutyric acid deficiency, the real inhibitory substance. This has led us to make a trial to establish a new experimental method as follows.

The method was to introduce γ-aminobutyric acid into the cerebrospinal fluid of dogs together with substances to change it into some unknown factor which would produce the generalized seizure[10]. In the experiment in Table 2, vitamin B_{12} was used instead of folic acid ; this had no effect by itself, but when combined with γ-aminobutyric acid and adenosine triphosphate, caused a seizure.

The preparation of adenosine triphosphate used was the sodium salt. The convulsant effect of sodium itself was considered. Sodium pyrophosphate is a strong convulsant when applied directly to the motor cortex of higher animals, or into cerebrospinal fluid, and its action has often been confused with that of adenosine triphosphate and that of pyrophosphate. Table 2 shows that the action of adenosine triphosphate must be due to its capacity to provide energy.

Table 2. SEIZURE DUE TO γ-AMINOBUTYRIC ACID AND VITAMIN B_{12}. 1 ML. OF EACH SOLUTION WAS USED

Substances	Concentration administered into cerebrospinal fluid (per cent)	Generalized seizure	Remarks
γ-Aminobutyric acid	0·02	–	
Vitamin B_{12}	0·0002	–	
γ-Aminobutyric acid + vitamin B_{12}	0·2 + 0·0002	–	
γ-Aminobutyric acid + vitamin B_{12} + adenosine triphosphate	0·02 + 0·0002 + 0·002	+	Latent period, 12 min.
Adenosine triphosphate	0·002	–	
Adenosine triphosphate + vitamin B_{12}	0·002 + 0·0002	–	

Table 3. SEIZURE DUE TO γ-AMINOBUTYRIC ACID AND VITAMIN B_1. 1 ML. OF EACH SOLUTION WAS USED

Substance	Concentration introduced into cerebrospinal fluid (per cent)	Generalized seizure	Remarks
γ-Aminobutyric acid	0·02	–	
Vitamin B_1	0·002	–	
γ-Aminobutyric acid + vitamin B_1	0·02 + 0·002	+	Latent period, 10 min.
Vitamin B_1	0·8	+	Latent period, 12 min.

Table 4. SEIZURE DUE TO VITAMIN B_1 WITH THE SUBSTRATES. 1 ML. OF EACH SOLUTION WAS USED

Substance	Concentration introduced into cerebrospinal fluid (per cent)	Seizure	Remarks
Pyruvic acid	0·02	–	
Pyruvic acid + vitamin B_1	0·02 + 0·002	+	Latent period, 10–12 min.
Citric acid	0·02	–	
Citric acid + vitamin B_1	0·02 + 0·002	+	Latent period, 11–12 min.
Succinic acid	0·02	–	
Succinic acid + vitamin B_1	0·02 + 0·002	+	Latent period, 12 min.

As shown in Table 3, γ-aminobutyric acid with vitamin B_1 at an appropriate concentration produced seizures with latent periods of 10 min. That the action of vitamin B_1 in this case is related to the energy liberation is shown by Table 4, where pyruvic, citric and succinic acids with vitamin B_1 at a subcritical concentration produced a seizure. The most probable interpretation of these effects of vitamin B_1 would be the energy liberation promoted to synthesize the excitatory mediator ; in other words, the action of B_1 is indirect.

In the biochemical methods hitherto used to detect the enzymatic action of tissues *in vitro*, homogenates or slices of tissue are incubated with the substrate and the consumption of oxygen, output of carbon dioxide or the appearance of the expected substances is measured. My new neurochemical method takes a seizure as an indicator. This is produced by substances added to the cerebrospinal fluid as substrates, coenzymes or energy liberators. Quantitative measurements can also be made by this method. Using it we obtained the following results.

(1) γ-aminobutyric acid is converted in some conditions to the excitatory mediator by cerebral tissue. (2) The excitatory mediator of higher animals is produced from γ-aminobutyric acid as substrate, through methylation by coenzyme, vitamin B_{12} or folic acid. (3) The process of conversion of γ-aminobutyric acid into the excitatory mediator requires energy which is supplied by a reaction involving thiamine. (4) γ-Aminobutyric acid is the parent substance to both the inhibitory mediator β-hydroxy-γ-aminobutyric acid) and the excitatory principle, which is presumed to be some methylated derivative of γ-aminobutyric acid.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Origin of Tektites

In a recent communication[1], Dr. Kohman suggests that tektites are meteorites which originate in interstellar space and collide with the solar system. I should like to direct attention again to the various facts that must be explained by any acceptable postulated history of these objects. (1) Tektites have chemical compositions remarkably similar to those of the more acid sedimentary rocks. This is true for the major and minor constituents. (I have been privileged to see analyses as yet unpublished on these minor constituents.) Such a chemical composition is not produced by any other naturally occurring chemical processes that we know of, except perhaps in very rare and special circumstances. (2) Tektites obviously have been melted, and this means that a temperature of some 1,500° C. or more was supplied by some means. In fact some appear to have been reheated to the melting point by passage through gas or by a blast of gas over the object. No terrestrial source of heat is known which could produce such high temperatures. (3) They are distributed thinly over areas of hundreds and thousands of kilometres in linear dimensions. (4) They are reported to contain aluminium-26 and beryllium-10. This observation is due to Dr. Kohman and Dr. Ehmann.

Dr. Kohman ignores items (1) and (2) above and gives us not the slightest indication as to how these objects could have accumulated, acquired their chemical composition and become melted in interstellar space. Apparently the problems that have concerned geochemists when a terrestrial origin is assumed become completely inconsequential when they are referred to the great cold vacuum far from the Sun. However, if items (1), (2) and (3) above could have been explained by non-miraculous means, neither Dr. Kohman, I, nor most of the readers of *Nature* would ever have heard of tektites.

Again I wish to direct attention to a suggestion I made last year[2], namely, that comet heads occasionally collide with the Earth, that such collisions would result in a flame-like mass of gas at a very high temperature capable of volatilizing the comet head and melting surface rocks of the Earth, and that high pressures capable of scattering bits of melted terrestrial materials over large areas would be developed. This was advanced in order to explain items (1), (2) and (3) above. The data of item (4) were not available at the time. It should be noted that Kohman and Ehmann's data required the lowest level counting technique that has been attempted and hence might well be checked by others, and that the terrestrial rocks used for comparison came from the glaciated area of Canada and an obsidian cliff in California, and hence they could scarcely have accumulated aluminium-26 and beryllium-10 from cosmic sources. Also, it may be that these elements could have been supplied from constituents of the comet head, though I am not particularly fond of this suggestion.

But comet heads should collide with the Earth from time to time. What effects should they produce? Would not something resembling the Alamagardo glass of the atomic bomb explosion be produced possibly or even probably? The energy of collision of a comet head with the Earth can reasonably be estimated as equivalent to some million or more atom bombs.

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Number of Elastic Constants required in Crystal Elasticity

In recent years there have been several publications by Laval[1], LeCorre[2] and other authors[3-5] suggesting a more general approach to crystal elasticity, which, among other features, requires for a triclinic crystal 45 independent elastic constants instead of the classical 21 (with corresponding increases in each of the crystal classes). The stress tensor is not symmetrical, and body couples (or volume couples) act in the crystal.

We show in this communication that in those cases in which the Laval–LeCorre theory is applicable the number of independent elastic constants actually is 39 and not 45. This reduction is brought about by means of energy considerations and the following hypothesis.

Given a crystal subject to mechanical strains only, a necessary condition for the appearance of body couples in a certain element of volume is that a deformation should be present. (It is not stated that this condition is sufficient.)

In the strain–energy function

$$W = \tfrac{1}{2}\sum_{i,j=1}^{9} c_{ij}\varepsilon_i\varepsilon_j \qquad (1)$$

the following substitutions are introduced:

$$\left.\begin{aligned}
\varepsilon_4 &= \varepsilon_{23} = \varphi_1 - \theta_1\\
\varepsilon_7 &= \varepsilon_{32} = \varphi_1 + \theta_1\\
\varepsilon_5 &= \varepsilon_{31} = \varphi_2 - \theta_2\\
\varepsilon_8 &= \varepsilon_{13} = \varphi_2 + \theta_2\\
\varepsilon_6 &= \varepsilon_{12} = \varphi_3 - \theta_3\\
\varepsilon_9 &= \varepsilon_{21} = \varphi_3 + \theta_3
\end{aligned}\right\} \qquad (2)$$

The meaning of the new variables is the following: $2\varphi_\alpha$ is the pure shear deformation $\left(\frac{\partial u_\gamma}{\partial x_\beta} + \frac{\partial u_\beta}{\partial x_\gamma}\right)$ and θ_α is the pure rotation $\frac{1}{2}\left(\frac{\partial u_\gamma}{\partial x_\beta} - \frac{\partial u_\beta}{\partial x_\gamma}\right)$ around an axis parallel to X_α in every element of volume. If these new variables are introduced into equation (1), the energy density W becomes a function of the ε_α, φ_α and θ_α ($\alpha = 1, 2, 3$), and it can be separated into three parts:

$$W = W_d + W_{dr} + W_r \qquad (3)$$

W_d has terms that contain pure deformations only (ε_α and φ_α); W_r has terms that contain pure rotations only (θ_α); the terms of W_{dr} contain both deformations and rotations.

The strains ε_i ($i = 1, 2, \ldots 9$) and all the other elastic variables are functions of position and time; but consider a point in which at a given instant the strains are such that no pure deformation is present, that is, ε_1, ε_2, ε_3, φ_1, φ_2 and φ_3 all vanish. When this happens, the strain tensor is antisymmetric, and the element of volume has performed the rotation $\vec{\theta}\ (\theta_1, \theta_2, \theta_3)$. If this rotation is now increased by $\delta\vec{\theta}\ (\delta\theta_1, \delta\theta_2, \delta\theta_3)$, then the change δW in the energy density is equal to δW_r (the other two increments, δW_d and δW_{dr}, are in this case equal to zero). But according to the hypothesis stated above, there are no body-couples acting on this element of volume, the stress tensor is symmetric, and the moment per unit volume due to the couples exerted by the stresses is zero. It follows that the value of δW_r must be zero too. This requires that the coefficients of the six terms of W_r should vanish. This condition leads to the six following relations (details will be given elsewhere):

$$\left.\begin{aligned} 2c_{47} &= c_{44} + c_{77} \\ 2c_{58} &= c_{55} + c_{88} \\ 2c_{69} &= c_{66} + c_{99} \\ c_{45} + c_{78} &= c_{48} + c_{57} \\ c_{56} + c_{89} &= c_{59} + c_{68} \\ c_{46} + c_{79} &= c_{49} + c_{67} \end{aligned}\right\} \quad (4)$$

which, in the four-index notation, can be summarized in this general condition:

$$c_{\alpha\beta\gamma\delta} + c_{\beta\alpha\delta\gamma} = c_{\alpha\beta\delta\gamma} + c_{\beta\alpha\gamma\delta} \quad (5)$$

The analogue of (5) in the Voigt theory is:

$$c_{\alpha\beta\gamma\delta} = c_{\beta\alpha\delta\gamma} = c_{\alpha\beta\delta\gamma} = c_{\beta\alpha\gamma\delta} \quad (6)$$

which follows from the vanishing of the coefficients of both W_{dr} and W_r in (3).

The physical meaning of keeping the second term W_{dr} in (3) is the following: the local rotations θ_u may contribute to the strain–energy function if a deformation is also present. It would, of course, be unjustified to call this contribution W_{dr} an elastic energy in the case of a rigid rotation, but it is part of the elastic energy in dynamic cases such as the propagation of elastic waves in crystals. In other words, rotations of undeformed elements of volume keep the strain energy invariant.

The new conditions (4) reduce by six the number of independent elastic constants: from 45 to 39. It is interesting to notice that, except in the triclinic and monoclinic classes, the last three of those six conditions are already satisfied by the elastic constants of Laval and LeCorre.

We have applied the conditions (4) to the elastic constants tabulated by LeCorre[2] in his paper of 1953, and have obtained thus the new matrices for each of the 11 Laue groups and for isotropic solids. These matrices will be published elsewhere. Table 1 summarizes the number of independent elastic constants for each of those 12 cases. The headings *V*, *LL* and *JW* correspond to the matrices of Voigt, Laval–LeCorre and ours, respectively.

Table 1

Laue group	*V*	*LL*	*JW*
$\bar{1}$	21	45	39
2/*m*	13	25	21
mmm	9	15	12
$\bar{3}$	7	15	13
$\bar{3}$*m*	6	10	8
4/*m*	7	13	11
4/*mmm*	6	9	7
6/*m*	5	11	9
6/*mmm*	5	8	6
*m*3	3	5	4
*m*3*m*	3	4	3
Isotropic	2	3	2

It can be seen that there is no distinction now between the elastic constants of Voigt and the new ones for the last two cases: the Laue group *m*3*m* and isotropic solids.

As an example, ammonium dihydrogen phosphate (class $\bar{4}2m$; Laue group 4/*mmm*) may be mentioned. Its elastic constants, of which new measurements will soon be reported elsewhere, do not fit into the Voigt matrix, but can be satisfactorily interpreted both with the matrix of Laval and LeCorre and the one suggested by us. It is interesting to note, however, that, while not all the nine elastic constants of Laval and LeCorre can be determined dynamically because the experiments only give the 7 values of c_{11}, c_{33}, c_{44}, c_{55}, c_{66}, $c_{12} + c_{69}$ and $c_{13} + c_{47}$, our conditions (4) reduce in this case to:

$$\left.\begin{aligned} 2c_{47} &= c_{44} + c_{55} \\ c_{69} &= c_{66} \end{aligned}\right\} \quad (7)$$

as a result of which the number of independent elastic constants is reduced from 9 to 7, and all of them can be determined by dynamic methods.

One of us (N. J.) gratefully acknowledges a research scholarship from the British Council while on leave of absence from the University of Chile.

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Effects of Pressure on some Optical and Electrical Properties of Diamonds

It has frequently been remarked[1] that although diamond crystals which are very efficient as conduction counters of ionizing radiations are usually free from birefringence, there is no strong correlation between counting efficiency and the degree of birefringence of counting crystals of average performance. Conversely, it may be inferred that the performance of diamonds as crystal counters will be almost independent of pressure at pressures which produce considerable artificial birefringence, and the following experiments have confirmed this supposition.

Satisfactory counting crystals were placed between two hardened steel electrodes which could be screwed together to apply pressures up to 10^4 atm. The pulse-counting technique could not be used directly as it proved impossible to separate the effect due to change in electrode capacity. However, the total β-ray bombardment current was observed and no significant change could be detected.

An alternative method of examining the effect of pressure on the width of the energy gap between the top of the valence band and the bottom of the conduction band is from measurement of the ultra-violet absorption cut-off wave-length. Using a spectrometer capable of resolving 1 A., no change in the cut-off wave-length was observed nor was there any alteration in the position of characteristic absorption bands at 2359 A. and 2363 A. As present theory indicates a change of only 10^{-8} eV. atm.$^{-1}$ in the width of the energy gap, these negative experimental results are consistent with theory.

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Measurements of the Permeability Tensor for 'Ferroxcube' at 24,000 Mc./s.

It is well known that ferrimagnetic materials become anisotropic upon application of a magnetic field and that consequently the permeability of a magnetically saturated ferrite medium is described by a tensor[1]:

$$\|\mu\| = \begin{Vmatrix} \mu & -jk & 0 \\ jk & \mu & 0 \\ 0 & 0 & 1 \end{Vmatrix}$$

For a positive and negative circularly polarized wave, the tensor is diagonalized, and the effective permeability is a scalar, $\mu \pm k$. The real and the imaginary parts of the elements of the tensor have been measured by several workers[2,3], using resonance cavities excited with circularly polarized modes. In order to study ferrite itself, it was pointed out by Spencer *et al.*[3] that it is necessary to determine the intrinsic magnetic quantities μ and k. Because of the radiofrequency demagnetizing fields the values $\tilde{\mu}$ and $\tilde{k}$ derived from the measurements depend on the sample shape. Those intrinsic values are computed from the experimental values using a magnetostatic approximation for the internal field.

Practically all measurements published hitherto have been carried out at 3,000 Mc./s. or 10,000 Mc./s.; most of them on American commercial products. We have measured the tensor components for the European commercial product 'Ferroxcube IV *B*' at 24,000 Mc./s. It is interesting to consider the position of μ at our working frequency on the dispersion and the absorption curves for the initial permeability. These dispersion and absorption curves can be interpreted[4] as a natural ferromagnetic resonance in the internal anisotropy field. 24,000 Mc./s. is situated beyond the anomaly of the dispersion curve. As a consequence, the residual magnetic losses are much smaller.

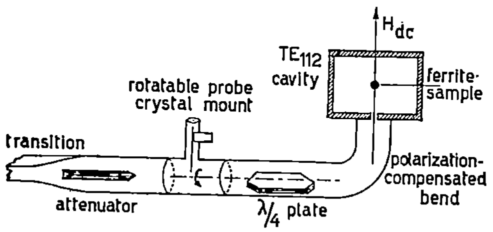

Fig. 1. Diagram of the circular polarizing device

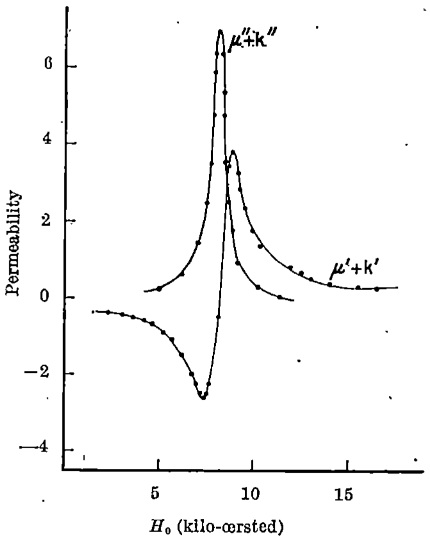

Fig. 2

In our measurements we have used a TE_{112}-reflexion cavity with ferrite spheres or disks placed in a position of maximum radio-frequency magnetic field and zero radio-frequency electric field. In order to excite the cavity, microwave radiation is fed through a circular polarizing apparatus constructed at our laboratory and shown schematically in Fig. 1. The sense of the circular polarization is reversed either by changing the orientation of the λ/4-plate or by reversing the d.-c. magnetic field. Care has been taken to avoid ellipticity in the circular guide and also on the adjustment of the quarter-wave plate.

The empty cavity resonates at 23,995 Mc./s. with a loaded Q-value of 3,985. Using the Bethe–Schwinger cavity perturbation theory, it is easily shown that the frequency shift, and the change in loaded Q, are directly proportional respectively to the real $(\tilde{\mu}' \pm \tilde{k}')$ and the imaginary part $(\tilde{\mu}'' \pm \tilde{k}'')$ of the effective permeability. For a sphere the intrinsic values are related to the experimental values by the equation:

$$\mu \pm k = -[2(\tilde{\mu} \pm \tilde{k}) + 1][\tilde{\mu} \pm \tilde{k} - 4]$$

The results of a typical run on a polycrystalline sphere with diameter 0·95 mm., using the apparatus described, are shown in Fig. 2. The values $\mu' + k'$ and $\mu'' + k''$ are plotted against the steady magnetic field. From other measurements on spheres and disks and with the aid of Kittel's relations for ferromagnetic resonance[5], we were able to calculate an effective value of g. We found a mean value of 2·11.

Further details will be published later.

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Anomalous Attenuation in Linear Electron Accelerators

WHILE operating the linear electron accelerator at the University of Ghent, interesting phenomena, similar to those reported on some accelerators in England[1-4], were observed. These phenomena have been explained on the basis of the multipactor effect[3].

Miller and Saxon[2] measured in a linear accelerator an attenuation of 2·5 db. for all power-levels, in the absence of the magnetic focusing field. In the presence of such fields, the attenuation was still found to be of the order of 2·5 db. for power fluxes of a few milliwatts and several megawatts. There was, however, a variation of attenuation with power in an intermediate range. They noted a maximum of 12 db. for an input power of 250 kW. If the power-level is increased, the attenuation falls, approaching 2·5 db. for an input of 3 MW. We consider that no satisfactory explanation has yet been given of the dependence of attenuation on power-level.

Considering a condenser-type field $E\sin(\omega t + \varphi)$ and using the same notation as Mullett, Clay and Hadden[3], the conditions for stable multipactoring are:

$$\mathrm{d} = \frac{e}{m} \cdot \frac{E}{\omega^2}\left[(2n + 1)\pi\cos\varphi + 2\sin\varphi\right]$$

and

$$0 < tg\,\varphi < 2/\pi\,(2n + 1)$$

where n is an integer. This leads to the fact that for each n the multipactor effect can occur in a stable way only between two limiting values, E_1 and E_2, of E. These intervals (E_1, E_2) are rather narrow. With increasing n, they become smaller and smaller, the fields needed decrease and the energy ε with which the electrons can arrive at the opposite plate decreases also. The electric field E, parallel with the axis of the accelerator, is for $a \leqslant r \leqslant b$ (b, radius of corrugations; a, radius of iris-hole) given by an expression containing Bessel functions. It turns out that this function can (at least for those parameters used for accelerators) be approximated rather well by a decreasing linear function of r:

$$E = \beta(b - r) \qquad (\beta > 0)$$

For a given value of n, the multipactor effect can occur only within a ring the radii of which, r_1 and r_2, are defined by E_1 and E_2. These rings are very narrow, especially for $n \neq 0$.

The area S of a ring is given by:

$$S = \begin{cases} 0 & \text{for } (b-a)\beta \leqslant E_2 \\ \pi\left[\left(\dfrac{E_2}{\beta} - b\right)^2 - a^2\right] & \text{for } E_2 \leqslant \beta(b-a) \leqslant E_1 \\ \pi\left[\left(\dfrac{E_2}{\beta} - b\right)^2 - \left(\dfrac{E_1}{\beta} - b\right)^2\right] & \text{for } E_1 \leqslant \beta\,(b-a) \end{cases}$$

S is maximum for $\beta = (E_1 + E_2)/b$. It is obvious that (for any particular value of n) S is directly proportional to the loss of energy. The fact that the anomalous attenuation is measured only in the presence of the focusing field can be explained satisfactorily. In the corrugations, there is not only an electric field E_2, but also a component H_θ, causing a radial force on the electrons which pushes them away from the regions where stable multipactoring is possible. The axial magnetic focusing field tends to prevent electrons from moving out of these regions. If the power flux through the accelerator is increased, the values of E_1 and E_2 are unchanged. The interval of r (r_1, r_2) where the effect can occur moves, however, toward the outside and falls off (Fig. 1).

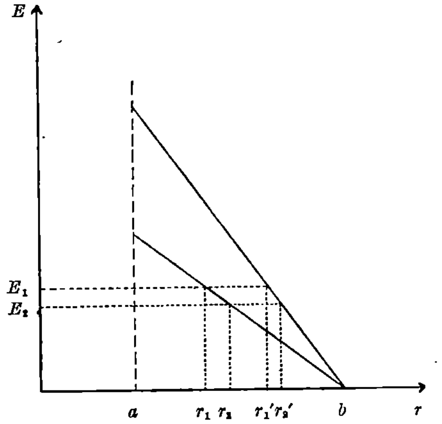

Fig. 1

For very low power-input, only high-n rings could occur. However, the effect will not be observed, because ε is so low that $\eta < 1$ (η, secondary emission coefficient). For very high power input, the lowest values of n could be reached, but then also the effect will not be produced, ε being so high that $\eta < 1$. Because of the larger area involved and the larger value of ε, the greater part of the loss of energy must be due to the inner ring that is possible in any particular case. In the experiment by Miller and Saxon, there was an attenuation of 10 db. for an input power of 250 kW. Taking into account only the ring corresponding to the lowest value of n, and supposing that there is only one cavity, one finds this attenuation for $\beta = (E_1 + E_2)/b$ for which $S = \pi b^2(E_1 + E_2)/(E_1 + E_2)$. This leads to an attenuation of 0·157 db. for an input power of 3 MW. Considering an accelerator with no other losses than those due to multipactoring, one comes somewhat nearer to reality. Then β is a function of z (co-ordinate along the axis). If the machine has a purely periodic structure, one can write:

$$\mathrm{d}P \sim \beta\mathrm{d}\beta = -C'S\mathrm{d}z \qquad (C' = \text{constant})$$

Using the third expression for S, this leads to

$$z = \frac{1}{2bC}\left[\frac{\beta^3(0) - \beta^3}{3} + \frac{E_1+E_2}{4b}\{\beta^2(0)-\beta^2\} + \frac{(E_1+E_2)^2}{4b^2}\{\beta(0)-\beta\} + \frac{(E_1+E_2)^3}{8b^3}\ln\frac{\beta(0) - (E_1+E_2)/2b}{\beta - (E_1 + E_2)/2b}\right]$$

$$(C = \text{constant})$$

Maximum attenuation will occur approximately for $\beta(l) = 3\;(E_1 + E_2)/4b$ (l, length of the accelerator) and in the considered case one finds 0·22 db. for an input power of 3 mW. This agrees well with the experiment.

We want to point out that even if the absolute losses of power were constant for different power-levels, we would find a low attenuation (0·34 db.) for 3 MW. if one assumed 10 db. for 250 kW. input.

Finally, it is interesting that the increase of the input power will also increase the radial forces which try to push the electrons away from the stable region, while E remains constant in the ring considered. This will decrease the losses due to the multipactor effect even more.

We wish to thank the Inter-University Institute for Nuclear Sciences (Belgium), which sponsored this work.

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A New Method of measuring Susceptibility

In recent years simple detectors of weak magnetic fields have become available. Magnetometers using the Hall effect in indium antimonide[1] or ferrite saturation[2] are capable of measuring fields of a small fraction of an œrsted, and they may be used in a magnetic circuit as detectors of magnetic flux, being analogous to a galvanometer detecting current in an electric circuit.

Using this principle, we have built the magnetic analogue of a Wheatstone bridge, with a permanent magnet as the source of magnetomotive force (Fig. 1). The magnetic detector (D) will register no flux when the reluctances of the four air gaps in the soft iron bridge circuit are equal, since the magnetic potentials at A and B will then be the same. If the reluctance of one gap is changed by inserting a sample with a permeability different from that of air, the bridge will become unbalanced and the detector will indicate the magnetic flux passing through it. The bridge may be initially balanced by moving a ferromagnetic screw in one of the gaps.

With gaps of 5-mm. length and $0 \cdot 5$-cm.^{2} cross-sectional area, and an *M*2021 Mullard 'Ticonal' magnet, a field of 1,500 œrsted is obtained in each gap. An InSb magnetometer unit, used in conjunction with a transistor oscillator and amplifier, can detect a field of 10^{-4} œrsted (Hilsum, C., and Thompson, N. A. C., unpublished work). Ideally, therefore, it should be possible to detect a departure from unit permeability by about one part in 10^7, that is, a susceptibility of 10^{-8} c.g.s. units.

The performance of an actual instrument is illustrated in Fig. 2. Measurements were made on aqueous solutions of nickel chloride the susceptibilities of which were calculated from the formula given by Nettleton and Sugden[3]. The calibration is essentially linear, and the instrument is quite capable of measuring diamagnetic susceptibilities such as that of de-ionized water. Our apparatus consists of two small boxes, about 8-in. cube, one of mumetal containing the bridge, and the other for the display meter and the electronics, which operate from a small internal dry battery.

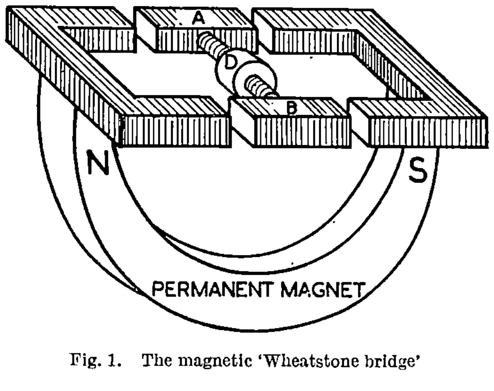

Fig. 1. The magnetic 'Wheatstone bridge'

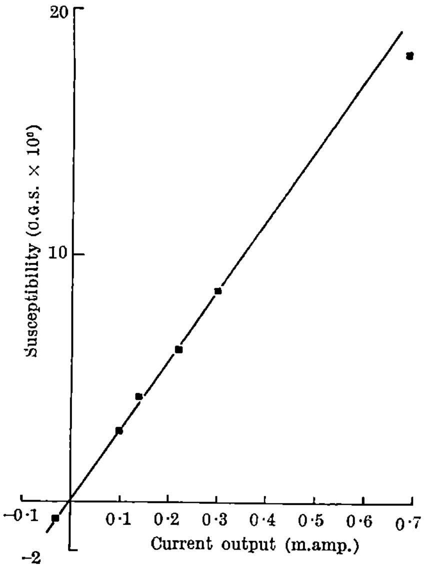

Fig. 2. Calibration curve of susceptibility meter

The instrument has the advantages over the usual susceptibility balance of being portable, unaffected by vibration and needing no external power supplies. It is, however, sensitive to variations in the local magnetic field, and measurements cannot be made while ferromagnetic objects are being moved near it. We have found the instrument to be very convenient for use both in the laboratory and in the open. A more detailed account will be given elsewhere.

We are grateful to the Admiralty for permission to publish this communication.

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Baldock, Herts. Sept. 15.

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Helium in Natural Gas in the Witwatersrand

During a visit to the Union of South Africa in the spring of 1957 I observed escapes of natural gas associated with faults and fissures in the underground workings of some of the gold–uranium mines of the Witwatersrand.

It seemed likely that as these major structures cut the uranium-bearing conglomerate horizons, the gas might contain appreciable quantities of helium. Arrangements were therefore made with Dr. J. J. Marais of the Anglo-Transvaal Consolidated Investment Co., Ltd., for a sample of gas to be collected from the Virginia Mine. This material has been analysed chemically and by mass-spectrometry. The results are shown in Table 1.

The high content of helium is of particular interest as the study of its distribution is likely to throw new

Table 1

	Chemical analysis	Mass-spectrometric analysis
Methane	78·4	76·6
Nitrogen	12·1 (by difference)	13·9
Helium	8·0	8·3
Hydrogen	0·1	0·1
Oxygen	0·1	0·2
Argon	0·3	0·5
Carbon dioxide	0·8	0·4
Carbon monoxide	0·2	—

light on the origin of the mineralization of the Witwatersrand System.

It is not known what volume of gas is available, but it would seem from present information that this field merits further study as a possible commercial source of helium.

I wish to thank the Director of the Geological Survey of Great Britain for permission to publish this communication, the Government Laboratory, London, for carrying out the chemical analysis, and the Mass-Spectrometer Group, Atomic Energy Research Establishment, Harwell, for carrying out the mass-spectrometric analysis.

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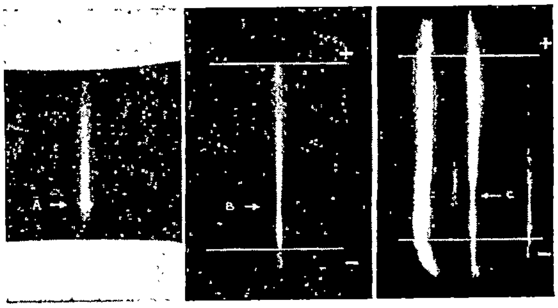
Observations on Overvolted Uniform Field Spark Gaps

The pre-breakdown processes occurring in a uniform field gap before a visible discharge takes place have been described by Townsend as the cumulative growth of ionization by successive generations of avalanches. The collision processes are mainly of the type defined by the ionization coefficient α. The criterion usually accepted as setting minimum breakdown voltage for a gap d is that $\gamma \exp(\alpha d) = 1$ where α and γ are the coefficients for the production of secondary electrons. If a spark gap has a voltage applied to it which is in excess of this minimum value then the avalanche growth mechanism will be similar, but the amount of space charge in one avalanche will be greater as it crosses the gap. If the voltage is sufficiently high, one avalanche can produce such a density of positive charge in its head that a 'streamer' or luminous filamentary channel will bridge the gap from the avalanche head. Depending on the voltage, this point from which the streamer growth starts can occur at almost any position across the gap. Meek[1] and Raether[2] gave the empirical relation $\alpha x_{cr} = 20$ for the critical avalanche-length x_{cr}.

Such a mechanism of growth has been observed in recent work with overvolted gaps using pulses of 0·1 μsec. duration applied to 2-cm. gaps in air at a p.d. of 800 mm.cm. Fig. 1*a* shows a typical cloud-chamber photograph of the charge distribution as the result of one avalanche attaining critical multiplication and forming anode- and cathode-directed streamers. This photograph clearly shows the avalanche head as a small cloud of ionization with the two filamentary discharges bridging the gap from the head to the anode and cathode respectively. If the voltage had been maintained for a sufficiently long period the external circuit would have discharged through these highly conducting columns.



(*a*) (*b*) (*c*)

Fig. 1 (*a*), Cloud-chamber photograph of streamer showing avalanche head at *A*. (*b*), Photograph of the light from a streamer showing constriction at *B*. (*c*), Photograph of the light emitted from several streamers. One shows a sphere in the constriction at *C*

Fig. 1*b* is a photograph of the light emitted from these streamers taken under similar conditions as Fig. 1*a* but without expansion of the cloud chamber. It can be seen that a constriction or 'neck' occurs at a point corresponding to the head of the avalanche in the cloud-chamber photograph. This suggests that the streamer has started from the avalanche head and widened out as it reaches the anode and the cathode. For longer pulses which allow the later stages to develop, photographs show that a filamentary discharge is formed, and its tortuous path is always contained within the existing streamer region.

If the discharge current increases above a certain value then emission of light increases within the constriction appearing as a small circle with the avalanche head as centre, see Fig. 1*c*. To an observer these points appear as bright beads of light much more intense than the remainder of the discharge. A fuller account of this work is to be published elsewhere.

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Sept. 4.

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Diffraction of Light by Ultrasonic Waves—Oblique Incidences

Various expressions have been obtained by several workers for the diffraction of light by ultrasonic waves[1] based essentially on the propagation of electromagnetic waves through a stratified medium. These expressions, being non-convergent, are limited in their scope and application[2]. Aggarwal[3] has given expressions for the intensity of different diffraction orders in a closed form which gives definite results under various experimental conditions. One such condition states that for low sound intensities in the medium, instead of the usual single maximum attained by the first three orders at their respective Bragg reflexion angles, $\alpha/2$, α and $3\alpha/2$, there are one, three and five reflexion maxima for the three orders respectively.

In order to verify this significant result we set up the usual diffraction apparatus of Debye and Sears and of Lucas and Biquard. The ultrasonic intensity was kept very low. The intensities of the diffracted orders were measured by means of a photomultiplier tube and read off on a scale, for successive small tilts of the quartz crystal from the normal incidence of the sound beam to light path. These angles of tilt were measured accurately by an optical lever system. We used ethyl iodide as the liquid medium giving sound of wave-length 0·0041 cm. at a frequency of 21·05 Mc. For the third-order reflexions, however, n-hexane was substituted giving sound waves of 0·0051 cm. at the same frequency.

The results for the first, second and third order of the diffraction pattern on one side are given in terms of the Bragg angle in Fig. 1. Here $\alpha/2$ is the reflexion maximum for the first order.

The first order shows a maximum at $\alpha/2$ only, while the maxima at $\alpha/2$, α and $3\alpha/2$ for the second order are unmistakably clear. $\alpha/2$, α, $3\alpha/2$ and 2α are the peaks for the third order line, but perhaps due to the low sound intensity and greater tilt of the quartz crystal the fifth one at $5\alpha/2$ does not make its appearance markedly. However, these results are in good agreement with Aggarwal's expressions.

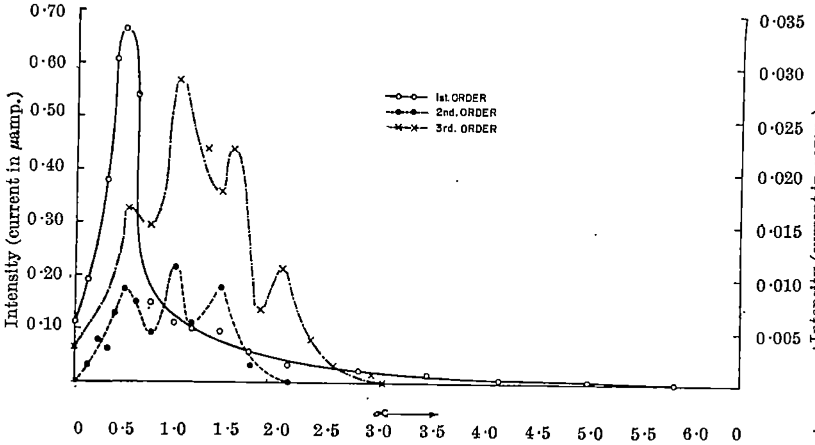

Fig. 1. The abscissa represents the reflexion angle α, and the ordinate (left-hand side for the first order and the right-hand side for the second and third orders) represents the intensity expressed in terms of the current in microamperes

It is of interest that a careful study of the photograph published by one of us[4] also shows the presence of more than one maximum for the second order.

Full details will be published elsewhere in due course.

S. Parthasarathy
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National Physical Laboratory,
New Delhi 12. July 22.

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Uptake of Molecular Oxygen by Ferrous Complexes

During the course of a deliberate study of models for iron porphyrin complexes of biological importance we have shown that ferrous dimethylglyoxime, $Fe(DMG)_2$, is capable of combining reversibly with molecular oxygen. The reaction occurs in a mixed solvent, 50 per cent aqueous dioxan, in which the complex is appreciably soluble in the presence of various added bases such as pyridine, ammonia, histidine and imidazole. The pH of the solution must be in the range 7–11 if the reaction is to be observed. We consider the reversible reaction to be

$$Fe(DMG)_2(base)_2 + O_2 \rightleftharpoons Fe(DMG)_2(base)\,O_2 + base$$

The forward reaction can be followed by the changes in absorption spectrum as oxygen is bubbled through the solution of the $Fe(DMG)_2(base)_2$ complex and the back reaction can be followed by observing similar changes bubbling pure nitrogen through a solution of the oxygenated complex. The spectrophotometric measurements show that the reaction is completely reversible for some of the complexes but that some autoxidation occurs with others. The changes in absorption spectrum with uptake of oxygen are very similar to those which occur on the uptake of carbon monoxide or cyanide by the complex. Both the liberation of oxygen and the liberation of carbon monoxide from the complexes have been studied manometrically. There would appear to be two complexes in one of which two molecules of oxygen or carbon monoxide are bound to the cation and, in the other, one molecule is bound as in the above equation. Comparison of the manometric and spectrophotometric measurements indicates that the first molecule of oxygen or carbon monoxide is picked up slowly but the second molecule is picked up so very slowly that the two stages of the reaction can be followed.

The rate at which oxygen replaces a base molecule in the above equation is sensitive to the base, as is the rate at which the oxygen molecule can be discharged afterwards. Oxygen is picked up most rapidly by the histidine complex and least rapidly by the pyridine complex. The evolution of oxygen is least rapid in the case of the pyridine complex.

Clearly these complexes parallel the behaviour of different biological complexes some of which pick up oxygen, some of which are autoxidizable and some of which are almost inert to oxygen. We hope to publish a detailed account of our observations together with a correlation between the properties of the models and the properties of the biologically important compounds shortly.

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Entropy Production in Irreversible Mechanical Processes

In discussing the concept of entropy, many authors relate the 'production of heat' or 'energetic heat evolution' ($\mathrm{d}Q_{\text{irrev.}}$) accompanying an irreversible process to the 'loss of useful work' and to the 'irreversible production of entropy' (d_iS) by an equation of the form[1]:

$$\mathrm{d}Q_{\text{irrev.}} = \mathrm{d}W_{\text{irrev.}} - \mathrm{d}W_{\text{rev.}} = T\mathrm{d}_iS \qquad (1)$$

where $\mathrm{d}W_{\text{rev.}}$ and $\mathrm{d}W_{\text{irrev.}}$ are, respectively, the amounts of work received by the system during a reversible and an irreversible change between the same initial and final states of the system; T is the absolute temperature of the system, supposed uniform throughout.

Now in an irreversible mechanical process, such, for example, as the impact of a hammer on a nail, or a frictional process, we observe a rise in temperature in the immediate neighbourhood of the process. Equation (1) cannot be applied until the temperature has been equalized—presuming always that the heat capacity of the surroundings is so large that no change in their temperature is observed. A question which then arises (particularly in the minds of students being introduced to these ideas) is whether it is possible to describe the system thermodynamically in the interval before the re-establishment of thermal equilibrium. The following outlines a way in which this may be done.

Consider, as an example, the impact of a body having a kinetic energy E, with a fixed anvil to which it becomes fused on impact. Suppose that the total heat capacity of body plus anvil (which together form 'the system') is C, and that after impact they are thermally isolated from the surroundings. If body, anvil and surroundings were at a temperature T_0 before impact, the system will have a temperature T_1 after impact, where

$$T_1 - T_0 = E/C \qquad (2)$$

An amount of mechanical energy E has disappeared, but now that the system is at a higher temperature than the surroundings it can act as a source of thermal energy to operate a reversible heat engine operating between T_1 and T_0. Action of the engine will lower the temperature of the system until it reaches T_0 again; this reversible reduction in T_1 to T_0 is accompanied by the performance of mechanical work by the heat engine.

Thus at the conclusion of the impact process, although mechanical energy E has disappeared, it is not all irrevocably 'lost' since some can be recovered by the use of a heat engine. It is readily shown that if in each cycle the heat engine removes an infinitesimal amount of heat from the system, then in lowering the temperature of the system from T_1 to T_0 (in an infinite number of cycles) an amount of work (W) can be recovered, given by:

$$\frac{W}{E} = 1 - \frac{T_0}{T_1 - T_0} \ln \frac{T_1}{T_0} \qquad (3)$$

The fractional dissipation of energy in the impact considered is thus equal to the second term on the right-hand side of (3). Formally, two limiting cases may be envisaged. First, if $E/C \rightarrow \infty$, $T_1 \rightarrow \infty$ and $W \rightarrow E$. Thus if 'the system' were infinitesimally small ($C \rightarrow 0$), all the kinetic energy could be regained as mechanical work from the heat engine. Alternatively, if $C \rightarrow \infty$, $E/C \rightarrow 0$, $T_1 \rightarrow T_0$, and $W \rightarrow 0$, the whole of the energy is dissipated.

This formal analysis is, however, subject to the limitation of all thermodynamic arguments, namely, that it must be restricted to assemblies of molecules large enough for statistical averages to have a physical meaning. Thus the primary process in an impact is the sharing of kinetic energy between the surface atoms of the two bodies over the area of impact. The motion imparted to them is an ordered motion, so that for the first 10^{-14} to 10^{-12} sec. after impact the 'temperature' of the surface atoms cannot be defined. This becomes possible only after sufficient vibrations have occurred to share this energy randomly among a sufficient number of molecules. What the present argument shows is that even when this randomization has occurred, only part of the mechanical energy has been rendered 'useless', the rest being recoverable, in principle, if temperature equalization with the surroundings is achieved through the medium of a reversible heat engine. If the initial rise in temperature is associated with a small part of the system, the major part of the 'irreversibility' of a mechanical process is to be associated not with the mechanical act itself but with the subsequent spontaneous flow of heat from the site of the action in the processes leading first to thermal equilibrium within the system and then to temperature equalization with the surroundings.

The subdivision of the total irreversibility will depend on the process considered. For example, in a collision between 'perfectly elastic bodies' the ordered motion is maintained as elastic waves which are reflected from the boundaries of the bodies and return to the point of impact to give rise to the 'restitutional force' which restores to the bodies the whole of the kinetic energy. The imperfection of real impacts presumably arises from the scattering of these waves throughout the bodies, possibly accompanied by some randomization near the site of impact. In a completely inelastic collision, the randomization may occur within a few molecular diameters of the surface with a large local temperature rise.

Essentially similar reasoning can be applied to the irreversible flow of an electric current through a conductor, and to spontaneous chemical reactions: the entropy production is associated to a major extent with the process of temperature equalization after the cessation of the primary phenomenon.

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[1] An equation of this form appears in many modern text-books; it has been discussed in particular by Brønsted in, for example, "Physical Chemistry" (trans. Bell), Chap. 1 (Heinemann, 1937); "Principles and Problems in Energetics" (trans. Bell), Chaps. 4 and 6 (Interscience, 1955). Cf. also Prigogine and Defay, "Chemical Thermodynamics", Chap. 3 (Longmans, 1954).

Surface Oxide Films and the Breakaway Corrosion of Uranium

During corrosion, the more reactive metals, for example, aluminium, zirconium, titanium and uranium, usually form a protective oxide film which reduces the corrosion-rate to a low value. Recently, it has been observed that this low corrosion-rate can increase suddenly and the phenomenon has been termed 'breakaway'. The cause of breakaway has not been finally established, but it appears that the effect is associated with a change in the protective oxide film.

Surface oxide films have been studied by many methods, one of which is to consider the oxide layer as the dielectric of an electrolytic condenser[1], the underlying metal forming one electrode and the corrosive liquid the other. By measuring the electrical capacity and leakage resistance of such a condenser, some estimate of the thickness and conductivity of the oxide can be made.

Wanklyn[2] has commented on the limitations of capacity measurements as a means of estimating oxide thicknesses when applied to the problem of breakaway corrosion of zirconium. In view of this it may be of interest to report some results recently obtained while applying a related method to the study of breakaway corrosion in uranium–water systems.

The experimental techniques, which will be reported in full elsewhere, permitted measurements to be made without disturbing the corrosion process, the results being expressed as the capacity and resistance of an analogue circuit consisting of a condenser and resistance in parallel.

Earlier work[3,4] has shown that the presence of hydrogen in solution in γ-uranium alloys is associated with an increase in corrosion-rate of about × 20. To study this effect measurements were made of the capacity and resistance of the oxide films on the surface of specimens which were free of hydrogen and on specimens into which hydrogen had been introduced, prior to the corrosion test, by cathodic charging.

The results show that the thickness of the films, as indicated by the capacity, is not changed by the presence of hydrogen in solution in the metal. The measured capacities were the same to within ± 10 per cent for the hydrogen-charged and hydrogen-free samples. However, a marked increase in the conductivity of the oxide is associated with the presence of hydrogen in the metal. The resistance of the oxide on the hydrogen-free specimens was greater than 10^6 ohm/cm.^{2}, whereas that on the charged samples was of the order 3×10^5 ohms/cm.^{2}.

While there are no data available on the hydrogen content of the oxide layers, it may be expected that increasing hydrogen content of the metal would be accompanied by increasing hydrogen content of the oxide. The mechanism by which hydrogen or hydrogen ions produce this change in resistance is not clear as, under the conditions of the corrosion reaction, there is no possibility of hydrogen reducing the oxide.

This work, which is continuing, was sponsored by the U.S. Navy, Bureau of Ships.

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Royal School of Mines,
Imperial College of Science and Technology,
London, S.W.7. Sept. 4.

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Kinetics of the Thermal Dehydration of Kaolinite

For the decomposition of a solid substance, one of the products being volatile, the following equation relating the kinetic parameters of the reaction to the results of thermogravimetric analysis was recently derived by Freeman and Carroll[1]:

$$\frac{\frac{-E}{2\cdot 3R}\,\Delta\,(T^{-1})}{\Delta\log w_r} = -x + \frac{\Delta\log dw/dt}{\Delta\log w_r}$$

In this equation E represents the energy of activation, x the order of the reaction, w the loss in weight of reactant up to time, t, and $w_r = w \;\; - w$, where w_c = loss in weight at completion of the reaction. R is the gas constant and T the absolute temperature. A plot of $\frac{\Delta\log dw/dt}{\Delta\log w_r}$ vs. $\frac{\Delta(T^{-1})}{\Delta\log w_r}$ then results in a straight line from which the parameters x and E are easily derived. For the purpose of this plot w_r can be determined directly from the thermogram as well as the values of dw/dt, the rate of change of weight of sample with time, when the thermogravimetric analysis is conducted at a constant heating rate.

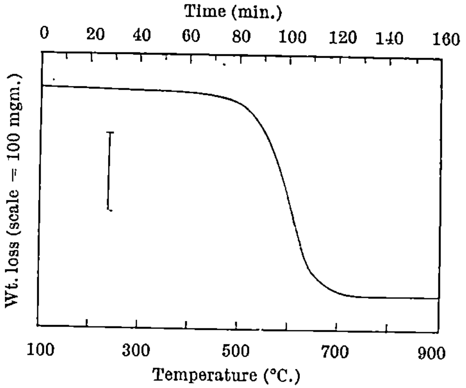

Fig. 1

The dehydration of kaolinite was studied as a function of the above equation. The sample consisted of the < 1μ fraction, separated by classical sedimentation and supercentrifuge techniques, from a commercially available kaolin (Whitehill pottery clay from Continental China Clay Co., Brussels). X-ray diffraction revealed a very pure monomineral composition in agreement with the results of chemical analysis, the figures in per cent of which are (after preliminary drying at 110° C.): loss on ignition (950° C.): 13·57; SiO_2: 46·76; Al_2O_3: 39·55; Fe_2O_3: 0·05; TiO_2: 0·05; CaO: 0·17; MgO: 0·02; Na_2O: 0·12; K_2O: 0·45. The thermogram, reproduced from 100° C. onwards in Fig. 1, was taken with a photographically recording Chevenard thermobalance (Société Adamel, Paris). The analysis was performed in air with a manually controlled constant heating rate of 5° per min. on a previously dried (150° C.) 2 gm. sample placed in a glazed porcelain crucible.

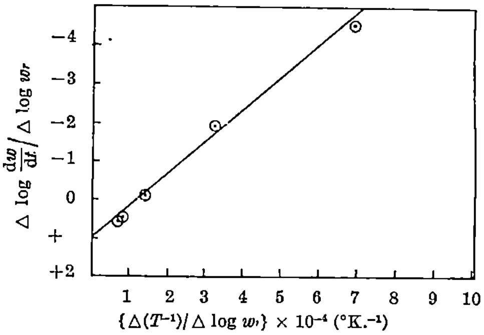

Fig. 2

Fig. 2 is a graph of $\frac{\Delta\log dw/dt}{\Delta\log w_r}$ vs. $\frac{\Delta(T^{-1})}{\Delta\log w_r}$. From this the following values for the order of reaction and the energy of activation are derived: $x = 1$ and $E \doteqdot 37\cdot 80$ kcal./mole.

Previously several authors, studying the kinetics of the dehydration of clay minerals by isothermal loss-in-weight measurements[2,3] and mathematical treatment of differential thermal analysis curves[4] (using Vold's method[5]), arrived at the same result with respect to the order of reaction. The values for the energy of activation calculated by these authors for kaolinite clays are respectively 44·00 (ref. 2), 44·83 (ref. 3) and 55·00 kcal./mole (ref. 4). The difference between the proposed value and the reported ones is to be allowed for by differences in composition and size of particles of the samples examined and by the different techniques involved (it is to be noted that the figures of refs. 3 and 4 apply to the same sample). With regard to the last factor the thermogravimetric method has a distinct advantage. In the isothermal method some dehydration may occur before the sample has reached the constant temperature of interest. The mathematical treatment of differential thermal analysis curves is concerned with the difficulty of correct choice of the transition point, and needs a correct determination of the heat capacity of the sample.

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Chemical Research Laboratory,
Ministry of Colonies,
Tervuren, Belgium. Aug. 5.

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An Overhauser Effect in Natural Crude Oil

WE have discovered an Overhauser effect in natural crude oil. The phenomenon was detected in a 12-ml. sample of oil in an H_0 field of 18·5 gauss (ν_p = 80 kc./s.; ν_e = 52·6 Mc./s.).

The Overhauser interaction occurs between the dissolved asphaltene free radicals and the hydrogen protons in the lighter hydrocarbons of the surrounding fluid. The electron resonance of these free radicals in petroleum has been previously investigated by Gutowsky, Ray, Rutledge and Unterberger[1]. The asphaltenes might well be considered as comprising a very stable colloidal suspension rather than being in solution. The molecular weights of the radicals vary from 20,000 to 40,000, and they can be precipitated by ultracentrifugation. The concentration of the asphaltenes in typical low viscosity crudes is of the order of 0·5–1 per cent. The electronic line-width in the kilomegacycle range is about 5 gauss.

The Overhauser interaction observed in the crude oil is negative; that is, the nuclear polarization at first declines with increasing intensity of the electronic radio-frequency field, becomes zero, and then builds up in opposition to the applied H_0 field. An electronic radio-frequency field (H_1) of about 0·25 gauss (at 52·6 Mc./s.) was required to drive the proton signal to zero in the specimen tested. Further increases in radio-frequency power beyond this value caused a rapid increase in the nuclear signal, in an inverted sense. The maximum available radio-frequency field, 1·1 gauss, produced an effective amplification of the proton signal of about × 15. The amplification (× 7) produced by an 0·8 gauss radio frequency field is illustrated in Fig. 1. So far as we know, the asphaltene radical is much the largest radical ever observed to produce an Overhauser polarization of solvent protons.

A rough calculation will suggest what strength of interaction is to be expected. The specimen was a highly fluid crude oil of viscosity about that of light machine oil—40 centipoise. A reasonable mean molecular weight for such an oil is 400, which leads to a molecular diameter of 10 A. If we assume the asphaltene concentration to be 0·5 per cent by weight (no accurate analysis was available for this oil), and the molecular weight to be 40,000, we find that there is one free radical for every 20,000 oil molecules. The average spacing of the radicals is therefore 270 A. From Stokes's relation, $D = kT/6\pi\eta a$, we can calculate the diffusion constant of the oil. This yields $D = 5 \times 10^{-6}$ cm.^{2}sec.$^{-1}$. A reasonable distance travelled by a typical oil molecule in the proton relaxation interval is $(DT_1)^{1/2}$. For the oil in question, T_1 was measured and found to be 186 msec. in a steady field of 18 gauss. The distance travelled by a typical proton in this time will thus be about 100,000 A. This is more than 300 times the spacing of the asphaltene radicals. The radicals occupy 3 per cent of the cross-sectional area of the solution. A typical proton, then, comes near a radical about ten times during the proton T_1 interval.

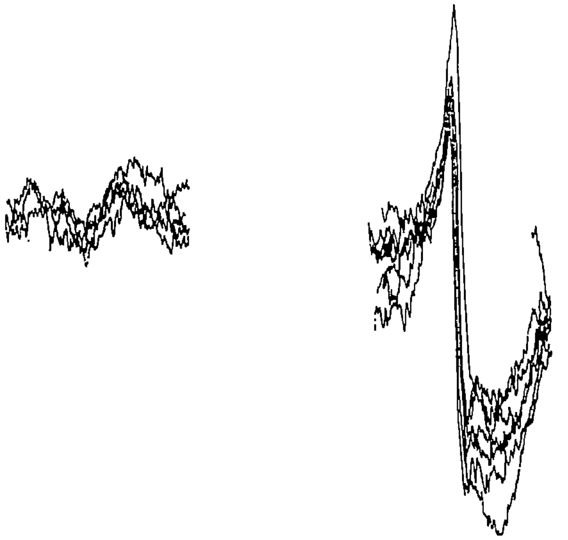

Fig. 1. Proton-resonance signals from crude oil, which demonstrate the Overhauser effect in the oil. Left, electron resonance not stimulated; right, stimulated by 0·8 gauss

At the highest available radio-frequency field the saturation parameter $S = (H_1/\Delta H)^2$ is 0·05. This would ideally lead to a proton signal amplification A of 15·5, from the relation[2] $A = 1 \cdot (S\gamma_e)$ $[2\gamma_p (1 + S)]$. The observed maximum negative amplification was about × 15. This may be rather fortuitous agreement, especially if it is considered that rather crude techniques of radio-frequency field measurement were used. It is seen, none the less, that the electron in the large asphaltene radical is essentially as effective in polarizing the adjacent fluid protons as those in much smaller radicals which have been studied to date.

EDWARD POINDEXTER

California Research Corporation,
La Habra, California. Sept. 16.

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Diffusion of Proteins through a Wedge-shaped Agar Gel

A WEDGE-SHAPED agar gel is formed by pouring out 10 ml. of a hot 2 per cent agar solution ('Bacto-Agar', Difco Laboratories) on a pre-warmed glass plate (16 cm. × 4 cm.), which is slightly inclined. After cooling down, the agar sets to a wedge-shaped gel. which measures 2·5 mm. at the thick end and 0·2 mm. at the thin end. It can easily be detached from the glass plate with a spatula. In the meantime another agar gel is formed, using the technique we have described for immune-electrophoresis[1]; 10 ml. of a hot 1·5 per cent agar solution are poured on a hot glass plate, as they are used in the 'Elphor' paper strip scanner. The agar gel, setting on the exactly horizontal glass plate, has a thickness of 1·5 mm. Now the wedge-shaped agar gel is laid upon it; this is done slowly so that no air remains between the two agar gels. Paper strips, 2 mm. broad, of Swedish 'Munktell' 20/150 paper are soaked in 2 per cent solutions of serum albumin (human), γ-globulin (Central Laboratory of the Swiss Red Cross, Berne) and α_2-macroglobulin (Behringwerke, Marburg/Lahn) in 0·86 per cent sodium chloride. These paper strips are laid parallel upon the wedge-shaped agar gel. After 24 hr. in a wet chamber they are removed and the agar wedge is placed on a glass plate. Both agar gels are now bathed in a 2 per cent solution of acetic acid for 2 hr. then they are dried under infra-red light and stained with amido-black.

The result shows that the thick end of the agar-wedge (Fig. 1*a*, left end) contains more of the proteins than the thin end. In Fig. 1*b* we find the proteins which have diffused through the wedge. There is slightly more serum albumin (mol. wt. 69,000, ref. 2) than γ-globulin (mol. wt. 152,000, ref. 2) and much less of the α_2-macroglobulin (mol. wt. 846,000, ref. 2).

With the same technique, but using oil red for staining, we followed the diffusion of β-lipoprotein (Behringwerke, Marburg/Lahn) and of β-lipoprotein as obtained from blood serum by dextran precipitation in the presence of calcium chloride[3,4]. The protein content of both solutions was 0·8 per cent.

The β-lipoprotein (Behringwerke, Marburg/Lahn), containing 75 per cent lipid and having an approximate molecular weight of 2,500,000, shows some diffusion (Fig. 2*b*), whereas the lipid content of the diffused precipitate is not high enough to be visibly stained by oil red. In order to increase the sensitivity we apply antiserum (horse) on the lower agar gel, after diffusion and removing the agar wedge. After 50 hr. the agar gel is thoroughly bathed in 0·86 per cent sodium chloride and non-reacting protein removed by elution. Fig. 2*c* shows what has diffused through the agar wedge. This time the paper strip was soaked in a 0·1 per cent solution of α_2-macroprotein (Behringwerke, Marburg/Lahn). The dilution compared with Fig. 1*a* is 1 : 20.

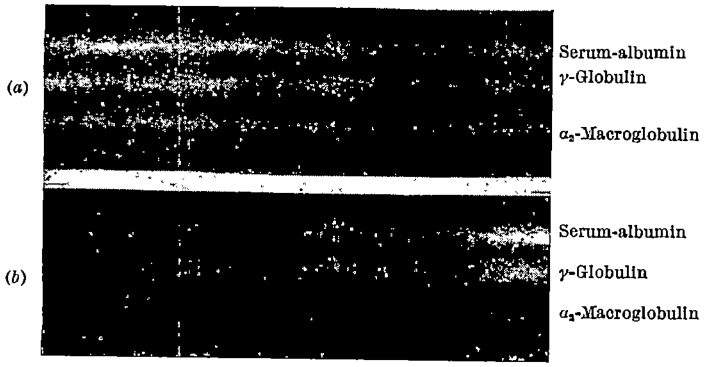

Fig. 1. (*a*). Proteins which have remained in the wedge-shaped agar-gel. (*b*) Proteins which have diffused through the above agar-gel. The thin end of the wedge is to the right

Fig. 2. (*a*) Lipoproteins which have remained in the wedge-shaped agar-gel. The thin end of the wedge is to the right. (*b*) Lipoproteins which have diffused through the above agar-gel. Oil red staining. (*c*) α_2-Macroglobulin that has diffused through the wedge-shaped agar-gel and has reacted with antiserum

The results show that the diffusion of monodispersed proteins through agar gel is slower with increasing molecular weight, but it would be difficult to give a definite value since it also depends on quantity, time and the factors which govern the structure of the gel.

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Sulphydryl Groups and Ribonucleic Acid

INVESTIGATION of rat and mouse liver prepared by solvent substitution[1,2] with 1 per cent mercuric chloride in absolute methanol has shown that a considerable portion of the cytoplasmic ribonucleic acid compounds combine with mercury. The nucleic acid compounds of the nucleus do not appear to combine with mercury under the experimental conditions used, that is, cooling to −190° C. and exposing to solvent at −65° C. for 48 hr. and then warming to room temperature. It is considered likely, though not conclusively proved, that the mercury has access to the nuclei during the solvent substitution.

Absorption curves of liver nuclei in tissue substituted with mercuric chloride and methanol are identical with curves of nuclei substituted with methanol alone. The absorption curve for the cytoplasm of methanol- and mercury-substituted tissue is not identical with that for methanol-substituted, but shows a shift downwards of a portion of the nucleic acid absorption. Experiments with nucleic acid bases in solution have shown that the presence of mercury shifts the absorption maximum down to approximately 245 mμ from 265 mμ. The shift observed in the cytoplasmic curve is taken as evidence of combination with mercury.

Digestion of 10μ sections with crystalline ribonuclease (1 mgm./ml. in glass-distilled water) removed all material staining with pyronin[3] in control sections, that is, methanol-substituted, after ½ hr. In methanol- and mercury-substituted sections the nuclear material staining with pyronin was removed after ½ hr., but there was still considerable cytoplasmic staining after 1 hr. digestion. Nuclear material staining with methyl green[3] was removed by ½ hr. digestion with crystalline deoxyribonuclease from both methanol and methanol and mercury tissue.

The absorption curves, enzyme digestion and staining reactions show that the nucleic acid compounds of the nucleus do not have reactive groups available for combination with mercury under the conditions used. The same criteria indicate that a portion of the cytoplasmic ribonucleic acid is associated with groups able to combine with mercury. Combination with purine and pyrimidine bases directly or with phosphate groups seems unlikely to select a particular portion of the nucleic acid compounds. It is known that mercury salts will combine with sulphydryl groups, and it is suggested that this is occurring during the solvent substitution.

Association of nucleic acid compounds with sulphydryl groups has been suggested as involved in polypeptide synthesis[4] and the polymerization of actin[5]. The importance of sulphydryl groups during cell division has been emphasized[6], and it has recently been shown that a diffusible nucleotide[7,8] is also involved; indeed it is possible that this nucleotide is hydrogen bonded to the spindle protein through a sulphydryl group. Hydrolysis by the nucleases involves phosphate groups, and the protection of some of the ribonucleic acid compounds by mercury may involve an association of phosphate and sulphydryl groups perhaps as previously suggested[9]. The intervention of sulphydryl groups in protein synthesis is indicated by work on sulphur-starved yeast[10]. If a part at least of the role of ribonucleic acid in protein synthesis is mediated by a bond involving a sulphydryl group, then the present evidence suggests that nuclear nucleic acid compounds do not intervene in protein synthesis at the same level as the cytoplasmic compounds.

A mechanism involving sulphydryl groups offers the possibility of control by other cellular systems controlling, for example, the level of oxidation. Such a mechanism, responsive to the state of affairs in the rest of the cell, would seem to be suitable as a primary step in protein synthesis. This would place the nucleus as intervening in protein synthesis subsequent to the cytoplasmic function. It is possible that a preliminary polymerization of amino-acids in the cytoplasm is followed by a further more specific polymerization of the units by the nuclear compounds. Recent work with tracers in cells synthesizing protein has also been interpreted as demonstrating the prior role of cytoplasmic ribonucleic acid in protein synthesis[11].

An account of the investigation of mercury solvent substitution will be published elsewhere.

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Mechanism of Chlorophyll Action in Photosynthesis

The use of tritiated water affords a sensitive means of answering at least one question about early photosynthetic events: Do any of the hydrogen atoms of the chlorophyll molecule intervene in the electron transport chain between water and oxidant? It has already been established[1] that all the hydrogen–carbon bonds of the chlorophyll molecule are sufficiently stable to prevent hydrogen exchange in neutral organic solvents in the dark; a tracer experiment is therefore feasible. At least one current school of thought maintains that the participation of hydrogen of the chlorophyll molecule in a chemical reaction is a requisite step in the electron transfer which originates in photoactivated chlorophyll[2]. Experiments in which *Chlorella* or *Scenedesmus* cells were illuminated in tritiated water have led us to the conclusion that some hydrogen of chlorophyll is activated during photosynthesis. A similar light-dependent and heat-sensitive activation of chlorophyll *a* and bacteriochlorophyll has been observed in a variety of cell-free preparations. The position in the chlorophyll molecule which is photochemically labilized is tentatively concluded to be C_{10}.

In the first experiments, *Chlorella* cells were suspended in tritiated water, and shaken either in the light or dark for 30 min. at 15° C., and compared with a dark control and a zero-time control. At the end of the experiment the suspensions were heated for 2 min. at 100°, the cells were lyophilized, and finally extracted with acetone. The chlorophylls were isolated by chromatography on sugar columns, and the purified material was counted in a windowless gas flow counter. Experiments 1, 2 and 3 in Table 1 show radioactivity associated with all chlorophyll samples; but chlorophyll derived from the illuminated incubation mixture has the highest specific activity. The radioactivity in the zero-time control sample was later shown to be the result of the short heat treatment, and could be reproduced with suspensions of pure chlorophyll in tritiated water. The position of tritium on the chlorophyll molecule made radioactive by heating is unknown. In subsequent experiments heating was omitted, and the algal cells were extracted without prior heating. It will be seen that in these experiments, Nos. 4 and 5, tritium is incorporated into chlorophyll only in the light. In one experiment the identity of the radioactive material with chlorophyll *a* was established by treating the biologically labelled material with 1 *N* hydrochloric acid and chromatographing the resulting phæophytin *a*. The specific activity of the phæophytin *a* was 1,155 counts per min. per mgm., and that of the original chlorophyll *a*, 1,145 counts per min. per mgm.

It will be noted that in these experiments chlorophyll *a* attained only a small fraction of the activity expected for complete equilibration of one position with the hydrogen of water. It is not known whether this reflects the participation of only a small fraction of the chlorophyll *a* in photosynthesis.

Greater differences between the tritium incorporation in the light and in the dark were observed in experiments with fragments of chloroplasts, which are known to carry out the Hill reaction. It can be seen in experiment 6, carried out with spinach leaf chloroplast fragments, that only in the light was a significant amount of tritium incorporated into the chlorophyll fraction. The absence of radioactivity from a previously heated sample indicates that the

Table 1. INCORPORATION OF TRITIUM INTO CHLOROPHYLL *a* AND BACTERIOCHLOROPHYLL

Experiment No.	Organism	C.p.m./μmole of chlorophyll				Time in min.	TOH c.p.m./μatom	Per cent equilibration
		Zero time	Boiled	Dark	Light			
1	*Chlorella* sp.	2·500		6,160	27,900	30		
2	,,			4,500	18,700	5		
3	,,			3,870	10,600	5		
4	,,		< 90	< 90	762	2		
5	*Scenedesmus nageli*		< 130	884	3,690	5	165,000	2·2
6	Spinach leaf chloroplast fragments		0	< 75	1,150	5	500,000	0·23
7	Acetone powder of spinach leaf chloroplast fragments			1,500	31,500	1	40,000	79
8	Chromatophores of *Chromatium*			0	6,500	1	40,000	16

incorporation of tritium is the result of an enzymatic reaction. Spinach leaf chloroplast fragments which have been extracted with acetone at −5° lose most of their chlorophyll, but retain a measurable part of it which is resistant to further extraction with acetone. Such acetone powder was suspended in tritiated water and exposed to light. This experiment, No. 7 in Table 1, shows that here, too, the chlorophyll becomes radioactive only in the light. This experiment is of particular significance since the specific activity of the radioactive chlorophyll indicates extensive equilibration with water. Probably only one hydrogen position participates in this reaction, and almost every molecule of chlorophyll in this reaction mixture has participated at least once. Experiment No. 8 was carried out with chromatophores of the purple sulphur bacterium *Chromatium*, prepared by Dr. I. C. Anderson of the Brookhaven National Laboratory. Like chlorophyll *a*, bacteriochlorophyll became radioactive in the light.

A number of observations suggest that the tritium on the radioactive chlorophyll *a* is located on C_{10}. Although the radioactivity remains associated with the molecule upon treatment with acid, all radioactivity passes into water when the labelled chlorophyll is treated with alkali. The label on chlorophyll *a* is quite unstable when the purified chlorophyll is exposed to air in the dry state, as for example, on nickel planchets or on paper chromatograms. This instability may be attributed to the allomerization reaction in which C_{10} is oxidized. It is thought likely that chlorophyll *a* tritiated in this position would be obtained by mild alkaline treatment of chlorophyll in tritiated water. Chlorophyll *a* was shaken in a mixture of 10 mc. of tritiated water with 0·02 ml. of pyridine in 1 ml. of ether for 12 hr. and was re-isolated by water–ether partition. The chlorophyll was found to be highly radioactive. Its radioactivity also was acid-stable, alkaline-labile, and unstable on prolonged exposure to air in the dry state. If in the previous experiments chlorophyll was indeed labelled in the C_{10} position, then chemically labelled chlorophyll *a* should be detritiated in similar reaction mixtures in the light. Table 2 shows experiments in which such detritiation by acetone powder of spinach leaf chloroplast fragments was carried out, occurred only in the light, and was heat sensitive. Attempts are in progress to purify the detritiating enzyme system and to identify possible co-factors. At this time the reaction system is in part bound to the insoluble part of the acetone powder suspension.

Table 2. LOSS OF TRITIUM FROM CHLOROPHYLL *a* LABELLED AT C_{10} DURING INCUBATION WITH ACETONE POWDER OF SPINACH LEAF CHLOROPLAST FRAGMENTS

	Residual c.p.m./μmole of chlorophyll *a*	
Zero time	148,000	
Boiled	153,000	after 30 minutes
Dark	149,000	
Light	122,000	

It is tempting to suggest that this light-dependent labelling of chlorophyll by tritium originating in water is the first step in the hydrogen transfer reaction chain in photosynthesis. There is at present one strong reason for believing that this labelling of chlorophyll is intimately related to photosynthesis. If triphosphopyridine nucleotide is added to the reaction mixture which contains a suspension of acetone powder and chemically tritiated chlorophyll *a*, there is in the light a substantial transfer of tritium from chlorophyll *a* to triphosphopyridine nucleotide. This tritium transfer must be the result of a series of reactions in which the intermediates do not exchange hydrogen with water, since any amount of exchange would have diluted the tritium below detection-levels. The details of these and related experiments will be presented elsewhere.

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Bacterial Preparation of Orotidine-5′-phosphate and Uridine-5′-phosphate

THE enzymic syntheses of orotidine-5′-phosphate and uridine-5′-phosphate have been reported by Lieberman *et al.*[1] and others. A chemical phosphorylation of uridine to form the 5′-phosphates has also been described by Hall and Khorana[2]. This communication describes the preparation of these previously rare compounds from cultures of *E. coli B* grown in a salts–glucose medium in the presence of the uracil analogue, *as*-triazine-3,5-dione, referred to as 6-azauracil.

It was reported previously that 6-azauracil inhibits the growth of various micro-organisms[3,4] and that nucleoside and nucleotide metabolities of the analogue could be isolated from the culture medium[5] or from the inhibited cells[6]. Using a modification of the method described by Skoda *et al.*[5] for the ribosidation of 6-azauracil by *E. coli B* to form 6-azauracil riboside (azauridine), large amounts of normal pyrimidine metabolities also were found in the medium. These have now been characterized as orotic acid, orotidine- and uridine-5′-phosphates. In a typical preparative run, 20 l. of a salts–glucose synthetic medium[8] containing 0·5 mmole/l. of 6-azauracil were inoculated with 2 l. of an uninhibited 18-hr. culture of *E. coli B* and incubated at 25° for 24 hr. without aeration. Growth, as judged by turbidity, was approximately one-third that of an uninhibited culture. The entire culture, without removal of the cells, was passed through a 100-gm. column of 'Darco' 20–40 granular charcoal, and the adsorbed pyrimidine derivatives were eluted with 50 per cent ethanol containing 2 per cent concentrated ammonium hydroxide. Following concentration *in vacuo* to a small volume, a crystalline precipitate was removed by filtration and characterized as ammonium orotate (700 mgm.). The filtrate was diluted, adjusted to *p*H 8·5, and passed through a 2 cm. × 20 cm. column of 'Dowex' 1 × 4 (formate) (200–400 mesh) anion resin. Elution with 0·1 *N* formic acid removed azauridine (1,140 mgm.) and a small amount of unconverted 6-azauracil. The solution of azauridine was concentrated to dryness, and the residue was recrystallized from water and ethanol. The column was then subjected to gradient elution with water and 1 *N* ammonium formate (*p*H 3·8) until two major ultra-violet-absorbing materials were removed. That the first of these was uridine-5′-phosphate (35 mgm.) was indicated by the ultra-violet-absorption characteristics and by ribose content, periodate titration, phosphate analysis, paper chromatography in four systems and perchloric acid digestion to release free uracil. The second substance was characterized in the same manner as the first; the analytic results indicated that it consisted of orotidine-5′-phosphate (73 mgm.). Both nucleotides were further purified by rechromatography on 'Dowex' 1 ion-exchange columns. The yields of uridine-5′-phosphate are variable, and in small-scale cultures occasionally none is found; yields of orotidine-5′-phosphate are generally greater when those of uridine-5′-phosphate are low. The reasons for this and further data on the mechanism of this accumulation are to be reported in detail elsewhere. From the charcoal eluates of a 625-gallon culture of *E. coli* inhibited by 6-azauracil, kindly supplied by the Squibb Institute for Medical Research, 65 gm. of orotic acid, 13 gm. of uridine-5′-phosphate and 6 gm. of orotidine-5′-phosphate have been isolated. Small amounts of phosphorylated derivatives of azauridine also were present in the charcoal eluate from the small-scale preparations and were recovered during ion-exchange chromatography. These correspond to those substances, previously referred to, which occur in the acid-soluble extract from *S. faecalis* cells[6] inhibited with 6-azauracil.

Apart from the preparative potential of this simple system for pyrimidine nucleotides, the significance of the accumulation of orotic acid and orotidine-5′-phosphate, with respect to the mode of action of the antimetabolite 6-azauracil, is apparent. A blockage in the utilization of pyrimidine derivatives at the ribotide level is suggested; in fact, enzymatic studies reported elsewhere[7] have attributed the interference to an inhibition of orotidylic decarboxylase.

It is of interest from a biosynthetic point of view that approximately 1 gm. of ribose in nucleoside or nucleotide linkage and 1·0 gm. of pyrimidine derivatives are produced in a salts–glucose medium from an inhibited culture which contained approximately 1 gm. (dry weight) of bacterial cells. In the absence of 6-azauracil there is little or no accumulation of these pyrimidine derivatives in the culture medium and the additional approximately 2 gm. (dry weight) of bacterial cells which would have been formed could not have contained more than 200 mgm. of pyrimidine-derivatives. It may be inferred that 6-azauracil acts not only to prevent further utilization of these nucleotides but also to suppress a mechanism which, under normal conditions of growth, limits their formation.

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Mode of Action of 5 : 6-Dimethylbenzimidazole and Certain Keto-Acids as Inhibitors of Hæm Biosynthesis

Abbott and Dodson[1] reported an inhibition by 5 : 6-dimethylbenzimidazole of the incorporation of ^{15}N-glycine into hæm by chicken erythrocyte preparations. Later work by Abbott, Dodson and Auvil[2] showed that this inhibition is at a step prior to the formation of δ-aminolævulic acid in the biosynthetic pathway. Recently, it has been reported[3] that the inhibition is to be located in those steps of δ-aminolævulic acid synthesis which involve either activation of glycine, in which pyridoxal phosphate is concerned, or condensation of the activated glycine derivative with succinyl-coenzyme *A*. Production of succinyl-coenzyme *A* itself is not inhibited by 5 : 6-dimethylbenzimidazole in the chicken erythrocyte preparations used[3]. Evidence has been presented recently[4] for the involvement of ferrous iron in the biosynthesis of δ-aminolævulic acid; work described at the same time showed that ferrous iron consistently diminished the inhibition by 5 : 6-dimethylbenzimidazole of δ-aminolævulic acid biosynthesis. Several other metal ions examined, including ferric iron, did not have this effect.

Present work has shown that riboflavin, a good chelating agent for ferrous iron[5], also inhibits the biosynthesis of δ-aminolævulic acid and that the inhibitions obtained with riboflavin, 5 : 6-dimethylbenzimidazole and α-α′-dipyridyl[4] are not additive (Table 1), so suggesting a similar mode of action as inhibitors, that is, the binding of ferrous iron.

If this hypothesis were correct it might be expected that 5 : 6-dimethylbenzimidazole would also inhibit the last stage of hæm synthesis, which involves the incorporation of ferrous iron into the porphyrin ring system. This was tested using lysed chicken erythrocyte preparations and assaying the incorporation of iron-59 into hæm. The method used was that described by Goldberg, Ashenbrucker, Cartwright and Wintrobe[6]. Table 2 shows the results so obtained, and Table 3 the results obtained from a parallel series of incubations in which porphyrin production was estimated by the method of Dresel and Falk[7]. Comparison of Tables 2 and 3 indicates an inhibition of hæm synthesis at two levels: (1) prior to δ-aminolævulic acid formation; (2) between protoporphyrin and hæm production. This finding confirms the hypothesis that 5 : 6-dimethylbenzimidazole inhibits steps requiring ferrous iron, the most likely mechanism being binding of the metal by co-ordination at the nitrogen atom (N_1) of the imidazole ring. It has been observed, in this connexion, that N_1-substituted benzimidazoles are without inhibitory effect.

Inhibition of hæm synthesis in bone marrow homogenates by α-oxoglutarate has been reported by Richmond, Altman and Salomon[9]. This inhibition has been demonstrated, in chicken erythrocyte preparations, to be located at those steps of δ-aminolævulic acid synthesis where 5 : 6-dimethylbenzimidazole mediates its effect[3]. Again, using extracts of *Rhodopseudomonas spheroides* which synthesize δ-aminolævulic acid, Shemin, Kikuchi and Bachmann[10] have shown an inhibition by both α-oxoglutarate and pyruvate. It has been suggested that inhibition by keto-acids might be attributable to a shunting of pyridoxal-5′-phosphate from δ-aminolævulic acid synthesis to transamination processes involving the added keto-acids[9]. Another school has suggested that pyruvate might compete with succinyl-coenzyme *A* for 'activated glycine'[11].

In view of the observation, already mentioned, that α-oxoglutarate appears to exert its inhibitory effect at a similar stage, in the biosynthesis of δ-aminolævulic acid, to 5 : 6-dimethylbenzimidazole, and taking into consideration the evidence obtained for the action of 5 : 6-dimethylbenzimidazole as a binding agent for ferrous iron, it seemed feasible that α-oxoglutarate and pyruvate might be acting in the same way. In this case, however, binding of metal ions would be expected to take place by chelation by the enol form of the respective keto-acids. Following this idea, experiments were conducted to examine the effect of ferrous iron on the inhibitions produced by α-oxoglutarate and pyruvate in chicken erythrocyte preparations which synthesize δ-aminolævulic acid without concomitant production of porphobilinogen or porphyrins[3]. The results, recorded in Table 4, show that ferrous sulphate produces marked alleviation of the inhibitions obtained with both α-oxoglutarate and pyruvate, so offering some support for the above hypothesis.

Table 1. NON-ADDITIVE INHIBITIONS OF δ-AMINOLÆVULIC ACID BIOSYNTHESIS WITH 5 : 6-DIMETHYLBENZIMIDAZOLE AND RIBOFLAVIN OR α-α′-DIPYRIDYL

Additions	δ-Aminolævulic acid (μmole)	Inhibition (per cent)
Exp. 1		
None	210	—
5 : 6-Dimethylbenzimidazole (2·7 m*M*)	44	79
Riboflavin (0·5 m*M*)	66	69
5 : 6-Dimethylbenzimidazole + riboflavin (0·5 m*M*)	43	80
Exp. 2		
None	220	—
5 : 6-Dimethylbenzimidazole (2·7 m*M*)	79	64
α-α′-Dipyridyl (1 m*M*)	172	22
5 : 6-Dimethylbenzimidazole (2·7 m*M*) + α-α′-dipyridyl (1 m*M*)	73	67

Incubations conducted under standard conditions (ref. 3) with 30 m*M* glycine and 30 m*M* citrate. Chicken erythrocyte preparation (ref. 3).

Table 2. EFFECT OF 5 : 6-DIMETHYLBENZIMIDAZOLE ON HÆM SYNTHESIS

Additions	Hæmin isolated (mgm.)	Activity of hæmin (^{59}Fe) counts/min./mgm.
Glycine (30 m*M*) + succinate (30 m*M*)	25·9	27
Glycine (30 m*M*) + succinate (30 m*M*) + 5 : 6-dimethylbenzimidazole (6·8 m*M*)	19·1	8
δ-Aminolævulic acid (0·4 m*M*)	12·8	22
δ-Aminolævulic acid (0·4 m*M*) + 5 : 6-dimethylbenzimidazole (6·8 m*M*)	21·6	9

Chicken erythrocyte lysate prepared and incubated as described by Goldberg *et al.* (ref. 6). ^{59}Fe-hæmin was isolated and counted as described by these authors.

Table 3. EFFECT OF 5 : 6-DIMETHYLBENZIMIDAZOLE ON PORPHYRIN SYNTHESIS

Additions	Uroporphyrin (μgm.)	Coproporphyrin (μgm.)	Protoporphyrin (μgm.)
Glycine (30 m*M*) + succinate (30 m*M*)	—	—	22
Glycine (30 m*M*) + succinate (30 m*M*) + 5 : 6-dimethylbenzimidazole (6·8 m*M*)	—	—	7
δ-Aminolævulic acid (0·4 m*M*)	131	75	401
δ-Aminolævulic acid (0·4 m*M*) + 5 : 6-dimethylbenzimidazole (6·8 m*M*)	137	80	420

Chicken erythrocyte lysate prepared and incubated as described by Dresel and Falk (ref. 8). Porphyrin separations and estimations were made following the procedure of these authors (ref. 7).

Table 4. EFFECT OF FERROUS SULPHATE ON THE INHIBITION OF δ-AMINOLÆVULIC ACID SYNTHESIS BY KETO-ACIDS

Additions	δ-Aminolævulic acid (μmmole)
None	154
$FeSO_4$ (1 m*M*)	118
α-Oxoglutarate (10 m*M*)	76
α-Oxoglutarate (10 m*M*) + $FeSO_4$ (1 m*M*)	106
Pyruvate (10 m*M*)	27
Pyruvate (10 m*M*) + $FeSO_4$ (1 m*M*)	65

Incubation conducted under standard conditions (ref. 3) with 30 m*M* glycine and 30 m*M* citrate. Chicken erythrocyte preparation (ref. 3).

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Colour Vision Studies and the X-Chromosome Constitution of Patients with Klinefelter's Syndrome

WE wish to report confirmation of the presence of two *X*-chromosomes in males with Klinefelter's syndrome and female nuclear sex and their presumptive 'sex-reversal'.

In 1949 Barr and Bertram[1] described a sexual dimorphism in intermitotic nuclei and suggested that the presence of 'sex-chromatin' (female nuclear sex) was dependent on the presence of two *X*-chromosomes. It has been assumed that the absence of 'sex-chromatin' (male nuclear sex) as in normal males, could be taken to imply an *XY* sex-chromosome combination. The validity of this identity is supported by many facts but does not amount to absolute proof. Caution is required in drawing conclusions from nuclear sexing about the *X*-chromosome constitution in anomalies of sexual differentiation, particularly those with apparent sex-reversal, because chromosomal anomalies are possible in these conditions and may lead to faulty inferences from the nuclear sex findings. Therefore the results of nuclear sexing in such cases should be confirmed by non-cytological genetic means[2]. The results of colour-vision studies can be used as tests of the *X*-chromosome constitution in groups of individuals with anomalies of sexual differentiation resulting in a discrepancy between somatic appearances and nuclear sex. Major red–green colour vision defects are determined by recessive genes located in the non-homologous portion of the *X*-chromosomes and therefore are much more common among males than among females, who must be homozygous for the genes in order to manifest the trait.

Colour vision tests on a group of subjects of female phenotype with evidence of 'ovarian agenesis' (gonadal dysgenesis) and with male nuclear sex, suggesting a male sex-chromosome constitution, showed that nuclear sexing had accurately depicted the absence of the *XX* chromosome combination and thus proved that they were not females in the sense of their sex-chromosome constitution[2]. It was not possible to obtain non-cytological genetic evidence on the *Y* sex-chromosome because of the absence of demonstrable complete *Y*-linked genes, though now that the work of Ford and his colleagues[3] has made direct detection of this chromosome possible the answer should be forthcoming. In Klinefelter's syndrome, a condition of sterility in males with abnormally small testes[4], a proportion of patients have a female nuclear sex pattern and the inference is that they have an *XX* sex-chromosome constitution. It was suggested[5] that their colour vision should be studied to confirm this and a preliminary assessment[6] showed a trend in this direction. The study has since been extended and the results to date are given in Table 1.

The incidence of major colour vision defects in the population of England, as tested on the Ishihara Tables, is 7–8 per cent for males and 0·65 per cent for females[7]. The figures for Switzerland are about 8 per cent for males and 0·43 per cent for females[8].

Table 1. Ishihara Colour Vision Tests in Patients with Klinefelter's Syndrome

	Total tested	Colour vision normal	Major colour vision defect: Observed	Expected if sample were of males*	Expected if sample were of females†
Patients with female nuclear sex (presumptive *XX*)	55‡	55	0	4·40	0·36
Patients with male nuclear sex (presumptive *XY*)	38‡	34	4	3·04	0·25

* Based on an 8 per cent incidence of major colour vision defects among males.

† Based on a 0·65 per cent incidence of major colour vision defects among females.

‡ 47 patients from Glasgow, 35 from London and 11 from Zurich.

The findings on colour vision in the sample of 55 chromatin-positive patients with Klinefelter's syndrome are significantly different from those that should be found in a sample of males, and therefore our results confirm the inference of nuclear sexing, that these patients, though phenotypic males, have in fact two *X* sex-chromosomes.

Recently, Ford and his colleagues[3] have found chromosome combinations of female type in a culture of bone marrow cells from one patient with Klinefelter's syndrome, thus giving the first direct cytological confirmation to the nuclear sexing result in the case submitted to them for study.

We are grateful to Dr. D. Ferriman for information about four of his patients included in the London series and to all the other colleagues who referred their cases to us.

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Lowering of an Auditory Threshold produced by a Light Signal occurring after the Threshold Stimulus

It has previously been shown that the interval between a warning signal and a subsequent stimulus will affect the threshold-level for perception of the stimulus[1,2]. When the interval between the warning signal and the threshold stimulus was kept constant, and was known to the subject beforehand, the threshold was lowest for a 1-sec. interval and was progressively higher for intervals of 2, 3, 4 and 9 sec. When the warning intervals were used in random order so that the subject did not know when, within the range, to expect the stimulus, the effect did not appear. This rules out an explanation in terms of intersensory facilitation.

This experiment has now been extended to warning intervals of 0, 0·3, 0·6, 0·9 and 1·5 sec. in one experiment and 0·05, 0·1, 0·15, 0·2 and 0·3 sec. in another, with the result that the threshold was lowest for the shortest interval in both cases. By analogy with reaction time and conditioning experiments, one might have expected the greatest 'readiness' and thus the lowest threshold to occur some time after the warning signal.

The following experiments confirm these results, and also extend the observations to the use of a 'warning' signal after the threshold stimulus.

The threshold stimulus was an increase, lasting about 50 msec., in the intensity of a 500-c.p.s. tone 60–70 decibels above threshold. The warning signal was a neon bulb lighting up. Another neon served as a 'get ready' signal before each trial, and the interval between it and the warning neon varied randomly between 2 and 7 sec., to prevent it acting as an effective warning. In each series of twenty trials, the interval between the 'warning' neon and the threshold stimulus was constant, and known to the subject. Four each of four intensities, and four zero or blank stimuli, occurred in each series in random order. The thresholds were calculated by probit analysis.

In the first experiment, intervals of −0·5 sec. (that is, the neon came on half a second after the threshold stimulus) and −0·1 sec. were compared with 'no warning' series, in which the second neon did not light up. In the second experiment, intervals of −0·1, 0 and +0·1 sec. were used. The simultaneous condition gave the lowest threshold, and even when the second neon came on 0·5 or 0·1 sec. after the threshold stimulus, it significantly lowered the threshold, as is shown in Table 1.

Table 1

	Experiment 1			Experiment 2		
Warning interval	'No warning'	−0·5	−0·1	−0·1	0	+0·1
Threshold (db.)	0·34	0·31	0·30	0·27	0·23	0·28
Standard errors	0·007	0·007	0·006	0·006	0·007	0·006
False positive rate (per cent)	10·0	6·3	8·1	8·8	7·5	11·9

These results might have been due to the subjects trying harder on some series. To exclude this possibility, a third experiment was done, in which trials under the −0·5 condition and the 'no warning' condition occurred in random order. The thresholds were 0·30 ± 0·013 decibel and 0·37 ± 0·010 decibel, and the false alarm rates 4·0 and 4·5 per cent, respectively, showing that the effect is still there even when 'set' is excluded.

These results imply that in experiments involving accurate threshold determinations not only should all possible preceding warnings be controlled but also any cues occurring up to at least 0·5 sec. after the stimulus. They also provide evidence that the effects of stimuli, unable by themselves to determine a perception or response, may be stored for brief periods.

That the threshold in these experiments is not lowered by intersensory facilitation is shown by the negative result in our earlier experiment with randomized warning intervals, and by the still large effect when the 'warning' occurs 0·5 sec. after the threshold stimulus. Experiments by Barlow[3] and by Tanner and Swets[4] have shown that the deliberate lowering of a visual threshold, by instructions or by motivation, results in an increased false alarm rate, and Barlow also found a decrease in the slope of the frequency of response curve when measured on a logarithmic scale. Both are unaffected by the changes in threshold in our experiments, suggesting that the lowering of the threshold is accompanied by, and may be the result of, a decrease in the effective 'noise' in the system. Such a decrease in 'noise' could be due to the 'warning' signal reducing the subjects' uncertainty about just when the threshold stimulus will occur. This uncertainty would be at a minimum when the 'warning' and the threshold stimulus are simultaneous.

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New Plant Growth-Substances with Selective Herbicidal Activity

The pronounced effect on plant growth-regulating activity that results from the introduction of chlorine atoms into certain positions of the benzene ring in benzoic and phenoxyacetic acids is well known[1], and some of these active derivatives, for example, 2 : 4-dichlorophenoxyacetic acid (2 : 4D), 2 : 4 : 5-trichlorophenoxyacetic acid (2 : 4 : 5T) and 2 : 3 : 6-trichlorobenzoic acid have become widely used for selective weed control. Systematic investigations with these groups of compounds have provided much information on the structural requirements necessary for high growth-regulating activity[2]. The influence of nuclear substitution on the activity of phenylacetic acids, however, has not received much attention, although some of these compounds have been examined (see Pybus[3]).

All the mono- and di-chlorophenylacetic acids, together with certain analogous trichloro-derivatives, have recently been prepared in this laboratory and their growth-regulating activity has been assessed in the wheat cylinder, pea segment and pea curvature tests[3]. During this investigation, the activity in the above three tests of all the corresponding benzoic and phenoxyacetic acids was re-examined for comparative purposes. With phenoxyacetic acids, high activity occurs only when a substituent group such as chlorine is present in the *para*-position of the ring; thus, for example, the 4-chloro-, 2 : 4- and 3 : 4-dichloro-, 2 : 3 : 4- and 2 : 4 : 5-trichloro-acids are all highly active[4]. In the benzoic series, however, compounds substituted in the *para*-position possess only weak activity; when this position is free, high activity is found to be associated with *ortho*-substitution. Thus the 2 : 3-, 2 : 5- and 2 : 6-dichloro- and 2 : 3 : 6-trichloro-benzoic acids are all active compounds[5].

With the phenylacetic acids, we have found that all the mono- and di-chloro-derivatives exhibit activity[3], the 2 : 3- and 2 : 6-compounds being extremely active. The high activity of 2 : 3- and 2 : 6-dichlorophenylacetic acids led logically to an examination of 2 : 3 : 6-trichlorophenylacetic acid and, as expected, this compound proved extremely active. The performance of these three acids in our standard laboratory tests, together with those of the corresponding benzoic and phenoxyacetic derivatives, are presented in Table 1, where comparable data for the activity of 2 : 4-dichlorophenoxyacetic acid are also given. The results clearly reveal the high growth-promoting properties of 2 : 3- and 2 : 6-dichloro- and 2 : 3 : 6-trichlorophenylacetic acids. It will be noted that the activity of the 2 : 3- and 2 : 3 : 6-derivatives in these tests was at least equal to that of 2 : 4D and far superior to that shown by the corresponding 2 : 3-dichloro- and 2 : 3 : 6-trichlorobenzoic and phenoxyacetic acids.

Table 1. GROWTH-PROMOTING ACTIVITY IN THE WHEAT CYLINDER, PEA SEGMENT AND PEA CURVATURE TESTS* OF 2 : 3- AND 2 : 6-DICHLORO- AND 2 : 3 : 6-TRICHLORO-DERIVATIVES OF BENZOIC, PHENYLACETIC AND PHENOXYACETIC ACIDS†. THE ACTIVITY OF 2 : 4-DICHLOROPHENOXYACETIC ACID IN THESE TESTS IS ALSO GIVEN

Acid	Concentrations tested (molar)														
	Wheat cylinder test :					Pea segment test :					Pea curvature test :				
	×10^{-7}	×10^{-6}	×10^{-5}	×10^{-4}	×10^{-3}	×10^{-7}	×10^{-6}	×10^{-5}	×10^{-4}	×10^{-3}	×10^{-7}	×10^{-6}	×10^{-5}	×10^{-4}	×10^{-3}
2 : 3-Dichlorobenzoic	101	102	109	*125*	*121*	100	102	105	*117*	*120*	0	0	1	2	3
2 : 6-Dichlorobenzoic	99	99	100	106	*141*	102	99	102	106	*116*	0	0	0	1	2
2 : 3 : 6-Trichlorobenzoic	103	109	*130*	*144*	*141*	104	*115*	*125*	*129*	*125*	0	2	4	6	6
2 : 3-Dichlorophenylacetic	*138*	*152*	*154*	*153*	*126*	103	*114*	*125*	*130*	*114*	1	4	6	6	2
2 : 6-Dichlorophenylacetic	102	109	*141*	*148*	*127*	100	*108*	*120*	*130*	*121*	0	3	6	6	2
2 : 3 : 6-Trichlorophenylacetic	*110*	*144*	*151*	*150*	*142*	*119*	*129*	*130*	*126*	*116*	4	6	6	6	2
2 : 3-Dichlorophenoxyacetic	99	99	100	105	*113*	101	100	98	*108*	*118*	0	0	0	3	4
2 : 6-Dichlorophenoxyacetic	101	100	100	105	*114*	103	102	107	*119*	*117*	0	0	2	4	2
2 : 3 : 6-Trichlorophenoxyacetic	100	100	99	102	*111*	100	102	107	*117*	*113*	0	0	1	3	2
2 : 4-Dichlorophenoxyacetic	*114*	*135150*		*154*	*128*	*112*	*122*	*127*	*125*	*115*	4	5	6	6	4

* The responses obtained in all tests were assessed after a 24-hr. treatment period. In the wheat cylinder and pea segment tests, activity is expressed as a percentage of the final length of control segments. Figures in italics are significantly different from controls at the 0·1 per cent level. In the pea curvature test, activity was assessed using a scale from 0 (inactive) to 6 (highly active).

† All compounds were examined at the stated concentration of the acid in the form of its sodium salt.

The marked activity of these three phenylacetic acids in our laboratory tests prompted us to investigate their effect on weed and crop plants. The results of experiments carried out to date indicate that all show selective herbicidal activity, and that the 2 : 3- and 2 : 3 : 6-derivatives are as effective as 2 : 4D in controlling many weed species. Further investigations on the herbicidal properties of these compounds and their effect on crop plants would appear to be warranted.

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Relationship between the Presence of Fungal Spores and a Test for Hepatotoxic Grass

FOLLOWING warm autumn rains after summers of above-average temperatures, rapidly growing pastures in some districts of New Zealand are capable of producing an hepatotoxin causing serious losses in sheep and cattle. A minority of the affected animals exhibit the clinical symptoms described as 'facial eczema'[1].

When heat-dried pasture samples containing the toxin are fed for 35 days, guinea pigs show liver damage. Using this tedious bio-assay technique, White[2] has been able to prepare extracts containing the toxin, but progress has been delayed through the lack of a specific chemical test. Recently, White[3] isolated a substance containing a major component of m.p. 260° C., and this has formed the basis of the so-called 'beaker test', a 4 hr. routine acetone extract procedure[4]. The occurrence of this substance in pasture samples, highest yield being 1 in 50,000 of dry weight of pasture, has been correlated with toxicity by Perrin and Sandos[5] and Clare and Sandos[6]. In spite of a good correlation, there is no evidence for chemical alliance between the 'beaker test' substance and the toxin. The purpose of this communication is to record the presence of fungal spores on pasture samples giving positive 'beaker tests'.

The original 'beaker test'–toxicity relationship was established from pasture samples obtained from the Claudelands Show Ground, Hamilton. Recently, on March 13, 1958, a positive 'beaker test' was obtained from pasture cut from this same area, and on March 15 fungal mycelia were observed on and about dead leaves and leaf bases of grasses. Direct isolation of hyphæ for growth on culture media showed that a species of *Sporidesmium*, identified by the Commonwealth Mycological Institute, Kew, as *S. bakeri* Syd. (Herb. I.M.I. No. 74473), was present in all samples examined. Other fungi isolated included a species of *Fusarium* and members of the Mucorales. On March 24, dark brown spore masses, consisting mainly of *Sporidesmium* spores, were observed on a gang-mower used to cut the Claudelands area. This material gave a positive 'beaker test'. Other samples of less pure spore material scraped from the mower were also found to give positive 'beaker tests', with the major component of m.p. 260° C. present at a level of 1 : 5,000.

Various strains of *S. bakeri* obtained from samples of mycelia on grass collected on March 15 were then grown on various media and a high sporing strain on particular media gave positive 'beaker tests'. Pasture samples collected daily between March 13 and 19 which had been dried were afterwards fed to guinea pigs. These tests showed that the toxin was present in the grass on March 15 and in the samples cut on each of the other days of this period.

Past work in which samples of toxic pasture have been dissected into dead and green portions has shown that stronger 'beaker tests' have been obtained from the dead material but that the toxin was present mainly in the green material. Positive 'beaker tests' have sometimes been obtained at intervals ranging from 0 to 14 days, before toxicity appeared, and pastures have produced positive 'beaker tests' for several weeks after the disappearance of the toxin. From this it will be clear that not all samples giving a positive 'beaker test' contain the toxin. However, it is only rarely that the toxin is found in samples not giving a positive 'beaker test'.

Recently a pure perennial ryegrass pasture at Palmerston North has caused facial eczema in sheep. Samples of these pastures supplied by Butler[7] have proved positive to the 'beaker test', and it is of considerable interest that direct microscopical examination of the surface of these leaves confirmed the presence of many *Sporidesmium* spores. A culture of *S. bakeri* has since been obtained from this material by direct hyphæ isolation.

These observations indicate that the substance giving the 'beaker test' reaction is contained in the spores of *S. bakeri*. E. P. White (personal communication) has confirmed this by isolation of the material with m.p. 260° C. in an impure state from cultured spores. An investigation is being carried out to determine whether this fungus also produces the toxin.

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Composition of the Nucleic Acids of Some Algae

As part of a study on the chemical composition of algae[1], the composition of the nucleic acids of various algae was investigated in order to determine whether there were differences between different groups of marine and freshwater forms. The following algae were studied: the freshwater diatoms *Navicula pelliculosa* (Bréb.) Hilse and *Nitzschia palea* (Kütz.) W. Sm.; the marine diatom *Cylindrotheca gracilis* (Bréb.) Grun.; the freshwater blue-green alga *Anacystis nidulans* (Richt.) Dr. and Daily; and the freshwater green alga *Chlorella pyrenoidosa* Chick.

The algae were grown in sterile culture. The flasks, containing 1·5 l. of suitable medium, were kept in a temperature-controlled room and illuminated from below with daylight fluorescent light. The algae were harvested every ten days to two weeks by centrifugation. *Navicula pelliculosa* and *Nitzschia palea* were grown at 22° C. in modified Chu 14 medium[2], illuminated intermittently and aerated. *Cylindrotheca gracilis* was grown in sea-water with a salinity of 17,000 p.p.m. with the addition of Ketchum and Redfield's medium[3]; a mixture of air and 2–5 per cent carbon dioxide was bubbled through the flasks. *Chlorella pyrenoidosa* was grown in modified Bristol's solution[4], illuminated continually and aerated with the air–carbon dioxide mixture. *Anacystis nidulans* was grown at 36° C. in Kratz and Meyers's medium[5], continually illuminated and aerated with the air–carbon dioxide mixture.

For the isolation of the nucleic acids and their separation into ribonucleic acid and deoxyribonucleic acid, the method of Ogur and Rosen[6] was used. Ultra-violet absorption spectra of all fractions were determined, and paper partition chromatograms were prepared. The most successful solvents were acidic butyl and propyl alcohol mixtures (*n*-butyl alcohol 77 : formic acid 10 : distilled water 13; or *iso*-propyl alcohol 68 : concentrated hydrochloric acid 17·5 : distilled water 14·5). Ribonucleic acid and deoxyribonucleic acid were hydrolysed with 3 *N* perchloric acid for 1½ hr. at 100° C. After determining their ultra-violet absorption curves, the hydrolysed samples were cooled in an ice-bath, neutralized with an ice-cold saturated solution of potassium hydroxide, filtered to eliminate the potassium perchlorate, concentrated *in vacuo*, and chromatographed. The purines and pyrimidines were eluted with 0·1 *N* hydrochloric acid according to Wyatt[7], and their amounts determined spectrophotometrically.

Repeated isolations and determinations of the ultra-violet absorption spectra of ribonucleic acid and deoxyribonucleic acid from all the organisms mentioned above showed no significant variations from the typical preparations of these acids from other sources. Samples of ribonucleic acid from all organisms showed the presence of the following purines and pyrimidines: cytosine, uracil, adenine and guanine. Cytosine, thymine, adenine and guanine were found in deoxyribonucleic acid. 5-Methylcytosine could not be detected in any of the algae studied. The quantitative data on the deoxyribonucleic acid from the algae were determined on the basis of millilitres of packed cells used. Although this is not an entirely accurate and reproducible unit, it is adequate for the determinations of the ratios of adenine/thymine, guanine/cytosine and purine/pyrimidine as previously determined by Wyatt for insect viruses[8]. The ratios varied from 1·01 to 1·10 for adenine/thymine, from 0·99 to 1·06 for guanine/cytosine, and from 1·01 to 1·09 for purine/pyrimidine (Table 1).

Table 1

Organism	Molar ratios in deoxyribonucleic acid		
	$\frac{\text{Adenine}}{\text{Thymine}}$	$\frac{\text{Guanine}}{\text{Cytosine}}$	$\frac{\text{Purine}}{\text{Pyrimidine}}$
Navicula pelliculosa	1·01	1·06	1·03
Nitzschia palea	1·09	0·99	1·04
Cylindrotheca gracilis	1·02	1·00	1·01
Anacystis nidulans	1·04	1·08	1·04
Chlorella pyrenoidosa	1·10	1·08	1·09

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Effect of Giberellic Acid on Leaf Form

RECENT reports[1,2] show that gibberellic acid affects the production of the juvenile or adult leaf form in plants. In the course of a study of the effect of physiologically active substances on heteroblastic development in *Ipomoea caerulea*, plants have been treated with various substances, including gibberellic acid. The observations so far made may be of interest in considering the effect of this substance on leaf form in other plants.

The substances used have been applied as drops (0·01 ml.) of aqueous solution on the cotyledons of 4–5 day-old seedlings. Indole-3-acetic acid, 2-4-dichlorophenoxyacetic acid, α-naphthylacetic acid, 2,3,5-triiodobenzoic acid and gibberellic acid have been applied in this way. The amount of substance applied was usually 10 μgm., except in the case of 2,4-dichlorophenoxyacetic acid, which was toxic in amounts greater than 5 μgm., and indole-3-acetic acid, which showed no appreciable effects unless applied in amounts of up to 50 μgm. As can be seen from Fig. 1 all these substances caused a delay in the change from the juvenile stage in which the leaves are entire (leaf shape index 1) or of low shape index (measured as described in previous work[3]), to the adult stage in which the leaves are tri-lobed and have a high shape index. 2,3,5-Triiodobenzoic and gibberellic acids, especially the latter, have particularly marked effects. This effect of gibberellic acid in maintaining the juvenile stage is similar to its effect on *Hedera* reported by Robbins[1], but in *Hedera* it is the juvenile leaf that is lobed while the adult form is entire, the reverse being the case in *Ipomoea*. In *Eucalyptus*, on the other hand, gibberellic acid produces the leaf-form characteristic of the adult plant[2]. The mechanism by which gibberellic acid produces these varying effects on leaf form is not yet clear. Brian[4] has suggested a possible mechanism of gibberellic acid action on flowering and germination.

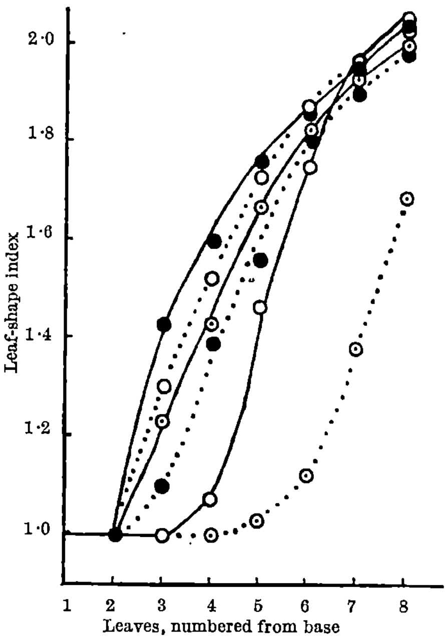

Fig. 1. The effect of various substances on leaf shape in *Ipomoea caerulea*. ●——●, control; ○ . . . ○, indole-3-acetic acid, 50 μgm.; ⊙——○, α-naphthylacetic acid, 10 μgm.; ● . . . ●, dichlorophenoxyacetic acid, 0·5 μgm.; ○——○, 2,3,5-triiodobenzoic acid, 10 μgm.; ⊙ . . . ⊙, gibberellic acid, 10 μgm.

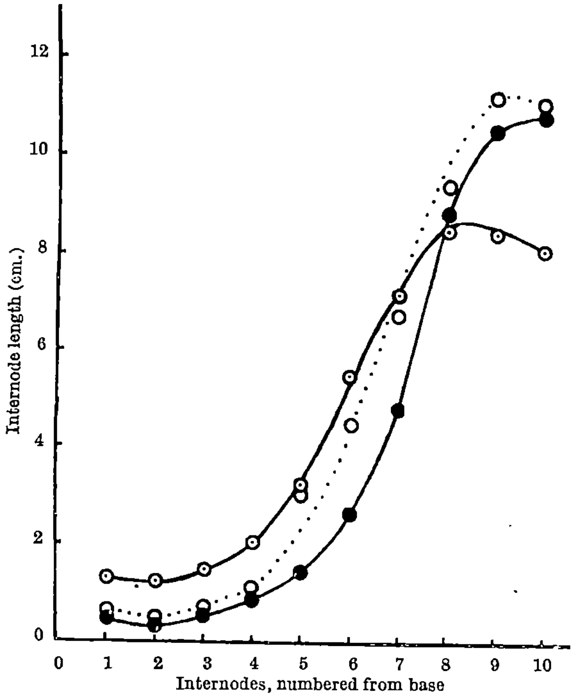

Fig. 2. The effect of 2,3,5-triiodobenzoic and gibberellic acids on internode-length in *Ipomoea caerulea*. ●——●, control; ○ . . . ○, 2,3,5-triiodobenzoic acid, 10 μgm.; ⊙——⊙, gibberellic acid, 10 μgm.

Further experiments with 2,3,5-triiodobenzoic and gibberellic acids have shown that, associated with their effects on leaf-form, are other changes in the growth pattern of treated plants. Both substances have a pronounced effect on internode-length, which is considerably increased (Fig. 2). The effect of gibberellic acid is, however, reversed at the higher internodes so that the height of the treated plants after four weeks growth is about the same as that of the control plants. This compensatory effect is similar to that observed by other workers and discussed by Humphries[5]. Dry-weight determinations made a week after treatment show that there are also changes in the distribution of growth between various organs (Table 1). Both substances have a stimulatory effect on shoot growth as shown by increased leaf production and increased stem and leaf weights. There is little or no effect on root growth, with the result that the root weight is a smaller percentage of total weight in treated plants. More work is required to show whether the change in root ratio is of fundamental importance in explaining the effect on leaf form. It is known that under conditions of shade when the juvenile leaf form is maintained the root ratio is low. Greater shoot growth and increased leaf production are also

Table 1. THE EFFECT OF GIBBERELLIC ACID ON GROWTH IN *Ipomoea caerulea*

Treatment	Leaf weight mgm./plant	Stem weight mgm./plant	Root weight mgm./plant	Total weight mgm./plant	Root weight as per cent of total	No. of leaves
Control	65·9	14·0	16·1	96·0	17·02	2·17
TIBA 10 μgm.	70·9	19·3*	15·0	105·2	14·64	2·42
GA 10 μgm.	95·8*	22·6*	19·0	137·5*	13·89	2·67

* Significant at $P = 0·05$.

TIBA, 2,3,5-triiodobenzoic acid; GA, gibberellic acid associated with the juvenile leaf form in *Ipomoea*[6]. Allsopp[7], discussing the effect of growth substances on heteroblastic development, suggests that the mechanism of the action of these substances in delaying the onset of the adult leaf form is through their effect in diverting nutrients from the apex to other organs thereby producing changes in the shoot–root ratio, generally inhibiting growth and depressing the activity of the apex. In *Ipomoea*, however, both 2,3,5-triiodobenzoic acid and gibberellic acid treatment increase shoot growth and leaf production, indicating increased rather than decreased activity of the apex. But there is a relative depression of root growth. Whether this reduced root growth has a causal relation to leaf form, for example, by bringing about a deficiency of phyllocaline or some other substance produced by the roots as suggested by Audus[8], requires further investigation.

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Occurrence of Gibberellin-like Substances in the Coconut

COCONUT milk contains substances which promote the growth of plant tissue cultures and isolated embryos. Some of these have been isolated[1,2] and one has been shown to be 1 : 3-diphenylurea[3]. Mauney *et al.*[4] have found a growth-factor which is mainly in the flesh of the coconut.

Substances which are physiologically gibberellin-like, in so far as they promote increased growth of genetic dwarfs of some plants, have been found in the immature seeds of a number of species of plant[5]. One of these has been identified[6] as gibberellin A_1. Experiments are described below which indicate that gibberellin-like substances occur in milk, flesh and embryos of the coconut. The growth-promoting properties of coconut milk may well be in part due to such materials.

Coconut milk was acidified to *p*H 2·5 and was stirred with activated carbon (20 gm./l.). The carbon was eluted with 70 per cent acetone. The acetone was then distilled off *in vacuo*, and the aqueous residue acidified and extracted with ethyl acetate. The ethyl acetate was dried and distilled off, and the residue was dissolved in ethanol and spotted on chromatography paper. Chromatograms were run in the following solvent system : chloroform/water/ethanol/formic acid (20 : 2 : 4 : 1). A chromatogram run from one spot was tested for gibberellin-like activity by the use of the wheat leaf section test[7]. Using this as a guide, the presumed active part of the main chromatogram was eluted with water and this was extracted with ethyl acetate. The eluate was concentrated and applied to the leaves of intact dwarf peas in ethanol.

The solid endosperm was macerated in a blendor with carbon tetrachloride to remove most of the oil. The solvent was filtered off, and the solid material was extracted with ethanol at room temperature overnight. The endosperm was filtered and pressed, and the ethanol solution was distilled *in vacuo*. The aqueous residue was filtered, acidified to *p*H 2·5 and extracted with ethyl acetate. The acid fraction was removed with 1 per cent sodium bicarbonate solution, which was acidified and extracted with ethyl acetate. This was concentrated and chromatogrammed as in the case of the milk. In this experiment the whole chromatogram was eluted in two parts, as the activity appeared to be spread over a large area.

The solidified coconut oil remaining when the carbon tetrachloride had been distilled off was stirred with water. The fat was filtered off after chilling. The water was then treated in the same way as the aqueous residue in the experiment described above.

Embryos found in some of the coconuts were extracted like the solid endosperm.

Table 1. GROWTH-RATE OF 'METEOR' PEA SEEDLINGS EXPRESSED AS PERCENTAGE OF THAT OF UNTREATED SEEDLINGS, AFTER APPLICATION OF EXTRACTS OF COCONUTS

Substance extracted		Fresh weight equiv. (gm.) of extract applied to each test plant	Days after treatment				
Exp. 1			0–2	2–5	5–9	9–12	12–16
Meat		457	218	314	256	219	200
Exp. 2			0–3	3–6	6–10	10–14	
Meat	R_F 0–0·4	166	181	307	309	184	
	R_F 0·4–1·0		195	184	136	87	
Oil	R_F 0–0·4		240	284	250	150	
	R_F 0·4–1·0		231	253	209	140	
Embryos	R_F 0–0·4	1·9	227	281	277	165	
	R_F 0·4–1·0		240	361	486	353	
Oil (embryos)	R_F 0–0·4		263	261	281	197	
	R_F 0·4–1·0		190	184	109	100	
Exp. 3			0–3	3–6	6–11	11–14	
Milk		188*	192	225	220	109	

* ml. of coconut milk.

The results given in Table 1 show that gibberellin-like activity was found in all parts of the coconut. The activity of the milk extracts cannot be directly compared with that from the meat, as a different sample of nuts was used. The activity of the extract of the embryos was remarkably high and needs to be confirmed ; this will be done when more coconut embryos are available. The nuts used in these experiments were fairly mature with a high proportion of solid to liquid endosperm. It is possible that younger nuts would contain more gibberellin-like activity, for whereas the embryos seem to contain an amount of gibberellin-like substances of the same order as young bean seeds[6], the endosperm contains much less, while in bean seeds the activity is distributed more or less evenly through all the tissues of the seed[7].

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Nitrate Content of some Grass Species and Strains

In the course of an investigation into possible sources of error in the determination of crude protein in herbage by the conventional method, a number of determinations of nitrate nitrogen were made. It is customary in this laboratory to use a reference herbage sample as a check in the routine. The nitrate nitrogen in this was determined first and found to be approximately 0·1 per cent. The reference sample is bulked from a large number of herbage samples, mainly grass, which pass through this laboratory. A nitrate content of this magnitude is therefore an average figure for several hundred samples and implies that some of the herbage which contributed to the reference sample may have contained considerable (possibly even nutritionally unacceptable) amounts of nitrate nitrogen.

Several grass samples which might be expected to show extreme amounts of nitrate nitrogen were selected for determination from an experiment in which eight species and strains of grasses grown as spaced single plants and in swards had been heavily manured with nitrogen. Samples were taken of the growth at successive dates for nitrate nitrogen determination. The results are given in Table 1. It is to be noted that the figures for each date represent the composition of the total growth of the herbage up to that date and not of regrowth after successive cuts.

Since an accumulation of mineral nitrogen must be regarded as being in excess of the plant's immediate needs or ability to use, the generally higher nitrate content of the spaced single plants is to be expected, as there would be less inter-plant competition for nitrogen than in the swards; the single plant plots had received the same dressing of nitrogen per unit area as the swards. It will be seen also that their total nitrogen, without exception, is substantially higher.

At the fourth and fifth dates of cutting the sward plants show nitrate contents similar to those of the spaced plants at the same dates. The fourth cutting date was only eight days after a dressing of nitro chalk, but at the fifth date, a fortnight later, there

Table 1. SHOWING CRUDE PROTEIN, TRUE PROTEIN, AND MINERAL NITRATE NITROGEN ON MANURED SWARDS AND SINGLE PLANTS

	(a) Swards			(b) Single plants		
	Total N per cent oven-dry material	Protein N as per cent total N	Nitrate N per cent oven-dry material	Total N per cent oven-dry material	Protein N as per cent total N	Nitrate N per cent oven-dry material
9/5/57	4 cwt. nitro chalk applied 18/3/57					
*S*23 Ryegrass (*L. perenne*)	1·74 (10·9)	78·5	0·003	No material available		
*S*24 Ryegrass (*L. perenne*)	1·55 (9·7)	79·3	Nil			
*S*170 Tall fescue (*F. arundinacea*)	1·65 (10·3)	76·8	Nil			
*S*59 Red fescue (*F. rubra*)	1·74 (10·9)	80·8	0·016			
*S*143 Cocksfoot (*D. glomerata*)	2·10 (13·1)	84·0	0·006			
*S*48 Timothy (*Ph. pratense*)	1·57 (9·8)	83·7	0·003			
*S*50 Timothy (*Ph. nodosum*)	2·02 (12·6)	83·7	Nil			
*Br*616 Bent (*Agrostis tenuis*)	2·10 (13·0)	82·4	0·006			
23/5/57	Further application 4 cwt. nitro chalk 13/5/57					
*S*23	2·19 (13·7)	77·4	0·035	4·24 (26·5)	75·1	0·365
*S*24	1·65 (10·3)	79·7	0·096	3·46 (21·8)	75·9	0·182
*S*170	1·89 (11·8)	78·0	0·051	3·17 (19·8)	77·7	0·109
*S*59	2·14 (13·4)	79·1	0·042	3·80 (23·8)	75·2	0·109
*S*143	2·80 (17·5)	80·7	0·074	4·81 (30·1)	78·4	0·343
*S*48	2·42 (15·1)	78·3	0·051	4·24 (26·5)	74·7	0·214
*S*50	2·53 (15·8)	81·0	0·064	4·65 (29·1)	77·3	0·195
*Br*616	2·67 (16·7)	79·7	0·048	3·74 (23·4)	76·1	0·141
7/6/57						
*S*23	1·65 (10·3)	83·5	0·022	2·94 (18·4)	75·0	0·138
*S*24	1·41 (8·8)	78·4	0·054	2·08 (13·0)	76·2	0·083
*S*170	1·71 (10·7)	76·6	0·054	2·36 (14·8)	73·6	0·055
*S*59	1·76 (11·0)	81·8	0·032	3·06 (19·1)	81·2	0·061
*S*143	2·25 (14·1)	82·3	0·038	3·84 (24·0)	82·1	0·163
*S*48	1·94 (12·1)	78·5	0·045	3·12 (19·5)	81·6	0·045
*S*50	1·86 (11·6)	82·7	0·035	2·88 (18·0)	74·4	0·086
*Br*616	1·98 (12·4)	79·8	0·016	2·74 (17·1)	79·5	0·042
20/6/57	Further application 4 cwt. nitro chalk 12/6/57					
*S*23	1·95 (12·2)	78·7	0·182	2·75 (17·2)	76·2	0·253
*S*24	1·79 (11·2)	76·8	0·243	2·08 (13·0)	80·7	0·121
*S*170	2·14 (13·4)	76·9	0·157	2·64 (16·5)	73·3	0·099
*S*59	1·68 (10·5)	72·3	0·269	3·37 (21·1)	77·7	0·137
*S*143	1·93 (12·1)	81·8	0·077	2·62 (16·4)	75·0	0·250
*S*48	1·36 (8·5)	77·1	0·090	2·75 (17·2)	77·9	0·128
*S*50	1·57 (9·8)	74·5	0·122	2·83 (17·7)	80·7	0·147
*Br*616	1·92 (12·0)	71·8	0·160	2·82 (17·6)	77·2	0·106
3/7/57						
*S*23	1·47 (9·2)	82·6	0·054	2·21 (13·8)	75·3	0·099
*S*24	1·34 (8·4)	84·5	0·112	1·74 (10·9)	77·0	0·051
*S*170	1·71 (10·7)	76·6	0·077	2·57 (16·1)	82·0	0·042
*S*59	1·41 (8·8)	77·3	0·128	2·97 (18·5)	82·2	0·042
*S*143	1·77 (11·1)	79·3	0·048	2·46 (15·4)	79·2	0·138
*S*48	1·30 (8·1)	79·0	0·080	1·55 (9·7)	78·3	0·035
*S*50	1·30 (8·1)	81·5	0·048	2·27 (14·2)	76·7	0·054
*Br*616	1·50 (9·4)	80·8	0·125	2·06 (12·9)	79·1	0·035
26/7/57						
*S*23	No material available			1·87 (11·7)	82·9	0·125
*S*24				2·10 (13·1)	83·2	0·099
*S*170				2·96 (18·5)	82·7	0·176
*S*59				3·30 (20·6)	80·1	0·150
*S*143				2·69 (16·8)	87·6	0·230
*S*48				1·70 (10·6)	77·6	0·072
*S*50				2·00 (12·5)	84·7	0·080
*Br*616				2·37 (14·8)	83·1	0·090

Figures in brackets are crude protein (N × 6·25).

was still a substantial residue of nitrate. The effect of the manurial dressing on the nitrate nitrogen of the swards is greater at the fourth and fifth dates than at the second and third, presumably owing to the slower growth and decreased metabolism of nitrogen at the later dates, which fell in a rather dry period, having only 0·92 in. of rain between June 10 and July 7, 1957. This is consistent with the finding of Ferguson and Terry[1] that applications of nitrogen late in the growing season resulted in increased amounts of nitrate nitrogen in the herbage.

It is to be noted from the results that a high total nitrogen is not necessarily a prerequisite for a high nitrate nitrogen content. A high nitrate, however, seems to be associated with a generally lower proportion of true protein nitrogen to total nitrogen.

The main interest of the present results, however, lies in the species and strain differences. In the spaced single plants, *S*23 perennial ryegrass and *S*143 cocksfoot are almost without exception considerably higher in nitrate than the remaining grasses. In the swards, however, *S*24 ryegrass has a considerably higher nitrate content than *S*23, while *S*143 cocksfoot no longer heads the list and in the last two cuts of the swards has actually the lowest nitrate content.

No attempt is made at this stage to offer any explanation of these species and strain differences in nitrate accumulation. The investigation continues and the results will be published elsewhere in due course.

Acknowledgment is made to Mr. Ll. Iorwerth Jones, who provided the material for analysis from a field experiment at this Station.

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A Direct-Plating Method for the Assay of Radioactive Isotopes in Aqueous and Alcoholic Samples

In the course of a programme of work on the determination of residue levels of γ-2 : 4-dichlorophenoxybutyric acid and related compounds in plants, the results of which will be reported in the Proceedings of the British Weed Control Conference, 1958, a rapid method was required for the radiochemical assay of non-volatile compounds labelled with carbon-14 contained in aqueous and alcoholic solutions.

A method for plating aqueous samples in which the compound to be assayed is incorporated into a film of dry agar has been published by McCready[1]. We are grateful to Dr. McCready for having described to one of us (H. C.) the basic principles of his method before publication. A modification of the method has proved to be free from complications due to coagulation of the agar when alcoholic solutions are to be assayed and a sample can be prepared for counting within 20 min. The precision, although not as high as that obtained by McCready, is adequate for many purposes, and this limitation is offset by the speed and convenience with which samples can be prepared for counting.

A measured volume of 0·1 per cent aqueous solution of agar is pipetted on to a planchette which has been washed with carbon tetrachloride. An equal volume of the aqueous or alcoholic solution of the sample to be counted is added and mixed by stirring with a fine wire. It is convenient to take a volume of 0·1 ml. of each solution when using a planchette 15 mm. in diameter and 2 mm. deep. The planchette is then placed on a hot plate at about 60° C. and allowed to dry; the thin film should be invisible.

When an end-window Geiger–Müller tube type *EW.3H* (20th Century Electronics, Ltd.) was used the count-rate per μgm. given by a sample of an organic acid of molecular weight 217 labelled with carbon-14 at specific activity of 0·46 mc./m.mole was 235 c.p.m. above background, that is, the counting efficiency was about 5 per cent. The precision of the method, tested by carrying out ten replicate determinations on samples of a solution containing carbon-14, was ±1·5 per cent under conditions where the statistical variation in counting should not have exceeded ± 0·6 per cent.

We thank Miss G. Mansfield for carrying out thorough independent tests of the technique, and the Directors of Messrs. May and Baker, Ltd., for permission to publish.

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Relationship of Serological Reactivity to Antibody Molecular Weight

In recent years information has been obtained concerning the molecular weight of antibody in relation to specific serological reactivity. Deutsch and Chan[1] found that human A and B *iso*agglutinins have molecular weight near 1,000,000. Paic[2] reported that rabbit anti-sheep hæmolysin had a minimum molecular weight of 420,000. More recently, Talmage *et al.*[3] found that the hæmolytic activity of rabbit anti-sheep hæmolysin was associated with antibodies of two distinct molecular weights. The bulk of the hæmolytic activity was associated with a high molecular weight antibody of greater hæmolytic efficiency and in addition a low molecular weight antibody of lower hæmolytic efficiency. Johnson *et al.*[4] reported that rabbit anti-human hæmolysin, in contrast to rabbit anti-sheep hæmolysin, has a molecular weight in the region of 160,000. We observed[5] that human anti-A and rabbit anti-human hæmolysin had the same complement-fixing capacity (the amount of complement capable of being fixed), while rabbit anti-sheep hæmolysin had a complement-fixing capacity 3–4 times lower.

On the basis of the above information and the comparison of the sedimentation characteristics of the agglutinin, hæmolysin and complement-fixing activities of human anti-A, rabbit anti-human and rabbit anti-sheep erythrocyte antibodies, we wished to determine the association of serological reactivity to antibody molecular weight.

Centrifugation was carried out in a 'Spinco' Model *E* ultracentrifuge. The sera were initially diluted 1 : 4 with veronal buffered saline *p*H 7·4. 11 ml. of the diluted serum was centrifuged 200 min. in an average field of 102,750*g*. Fractions were taken from the top, middle and bottom of the tube in 4, 4, and 3 ml. amounts. The agglutinin, hæmolysin (H_{50} units/ml.) and complement-fixing ($C'F_{50}$ units/ml.) titres were determined as previously described[5,6].

The results presented in Table 1 indicated that: (1) There was an association of hæmolysin and complement-fixing activities with antibodies of similar molecular weight, in human anti-A and rabbit anti-human serums, as shown by the consistency of the ratio of $H_{50}/C'F_{50}$ titres in the whole serum and the various fractions. (2) The $H_{50}/C'F_{50}$ ratio of rabbit anti-sheep serum did not show this consistency and indicated a closer association of hæmolytic activity with higher molecular weight antibodies and complement-fixing activity with lower molecular weight antibodies. (3) Both hæmolysin and complement-fixing activities of human anti-A serum appear to be attributable to antibodies of low molecular weight, as judged by the similarity in the relative hæmolytic activity of the fractions of rabbit anti-human serum which has been found to be of low molecular weight[4]. (4) The hæmolytic activity of human anti-A antibodies which cross-react with sheep cells were of very high molecular weight, as shown by the fact that 70 per cent of this antibody was found in the bottom fraction. (5) The comparison of the relative agglutinin activity in the fractions of each serum indicated that this activity in all three serums was associated with antibodies of high molecular weight.

Table 1. RELATIVE ANTIBODY ACTIVITY IN ULTRACENTRIFUGE FRACTIONS

Fraction	Titres			Ratio: $H_{50}/C'F_{50}$	Relative activity from top to bottom		
	Agglu.	H_{50}/ml.	$C'F_{50}$/ml.		Agglu.	H_{50}	$C'F_{50}$
Human anti-A and A cells							
Whole	128	5·8	5·2	1·1	—	—	—
Top	32	2·4	2·1	1·1	1	1·0	1·0
Middle	64	4·8	4·5	1·1	2	2·0	2·1
Bottom	256	10·5	9·3	1·1	8	4·4	4·4
Rabbit anti-human and human cells							
Whole	256	31·8	53·7	0·59	—	—	—
Top	128	11·2	20·8	0·54	1	1·0	1·0
Middle	256	23·0	42·1	0·55	2	2·1	2·0
Bottom	1,024	52·6	93·3	0·56	8	4·7	4·5
Rabbit anti-sheep and sheep cells							
Whole	128	2,940	435	6·8	—	—	—
Top	32	926	175	5·3	1	1·0	1·0
Middle	64	1,850	328	5·6	2	2·0	1·9
Bottom	256	6,190	910	7·6	8	7·5	5·2
Cross-reaction of human anti-A and sheep cells							
Whole		16·0					
Top		1					
Middle		6·1					
Bottom		42·0					

The complement-fixing activity of rabbit anti-sheep serum was associated with antibody of low molecular weight, unlike the bulk of the hæmolytic activity, which was represented by high molecular weight antibody. However, a comparison of the complement-fixing capacity of these fractions showed no change in the amount of complement capable of being fixed by the various fractions in spite of differences in the ratio of high and low molecular weight antibodies occurring in the fractions.

In contrast to the normal human *iso*agglutinins and similar to the human 'incomplete' Rh antibodies[1], human *iso*hæmolytic and complement-fixing activities were associated with antibodies of low molecular weight. The serological reactivity of rabbit anti-human serum was quite similar: agglutinin activity was associated with high molecular weight antibody and hæmolysin and complement-fixing activities were associated with lower molecular weight antibody.

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Further β-Globulin Phenotypes in Sheep

IN a preliminary communication eight sheep β-globulin types were described[1]. This number has now been increased partly by recognition of the fact that the two strongly staining zones *C* and *D* can be resolved into a third zone, and partly by the discovery of further types during examination of five hundred samples of sheep serum from Chelmsford abattoir.

The fourteen phenotypes which have been found so far (Fig. 1) probably represent the ten heterozygotes, and four of the five homozygotes of five β-globulin alleles, sheep β^A, β^B, β^C, β^D and β^E.

In keeping with the phenotype nomenclature suggested for the cattle[2] and goat[3] β-globulin systems, the phenotypes have been named sheep β^{AA}, β^{AB} . . . β^{EE}, representing the individual genotypes β^A/β^A,

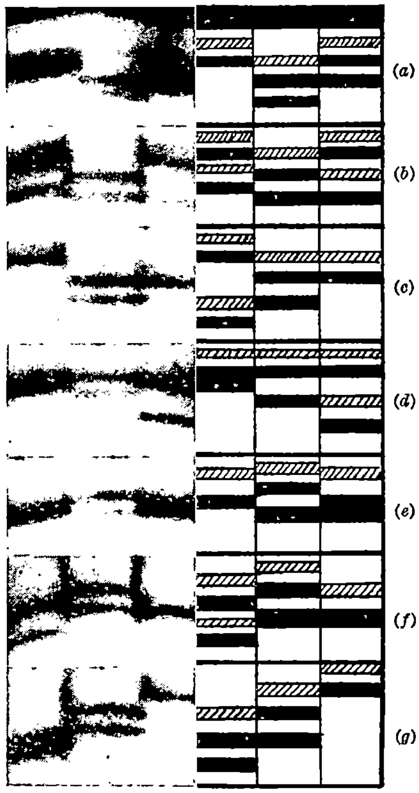

Fig. 1. Fourteen sheep β-globulin phenotypes. The illustration shows the β-globulin region of seven starch-gel electropherograms, each gel carrying three sera. The phenotypes are, from left to right on each gel, (*a*) β^{AA}, β^{BD}, β^{AB}; (*b*) β^{AC}, β^{BD}, β^{AD}; (*c*) β^{AE}, β^{BD}, β^{BB}; (*d*) β^{BC}, β^{BD}, β^{BE}; (*e*) β^{CC}, β^{BD}, β^{CD}; (*f*) β^{CE}, β^{BD}, β^{DD}; (*g*) β^{DE}, β^{BD}, β^{AA}. The trailing edge of the albumin zone is shown at the top of gel (*a*) for orientation

β^A/β^B, . . . β^E/β^E. So far the homozygote β^{EE} has not been found.

Each allele produces two zones in starch gel, an intensely staining zone preceded by a less intensely staining zone[3] (Fig. 1). In types involving combinations of β^B, β^C and β^D, the fainter zones are not seen because of the superimposition of the intensely staining zones. Distinction between the sheep β-globulin types is best made by reference to a β^{BD} serum run on the same gel.

120 different matings are possible with the five-allele system proposed. Some of the mating data obtained so far (from the Kerry Hill flock at the Farm Livestock Research Centre) is shown in Table 1.

Table 1. β-GLOBULIN MATING RESULTS FROM EWES MATED WITH A β^{BB} RAM

Mating	Phenotype of offspring				
	AB	*BB*	*BC*	*BD*	*BE*
BB × *AB**	2	2	-	—	—
BB × *AD*	0	—	—	1	—
BB × *AE*	0	—	—	—	2
BB × *BB*	—	1	—	—	—
BB × *BC*	—	5	2	—	—
BB × *BD*	—	0	—	2	—
BB × *BE*	—	0		—	1
BB × *CC*	—	—	1	—	—
BB × *CD*	—	—	2	5	—
BB × *CE*	—	—	2	—	0
BB × *DD*	—	—	—	1	—

* *AB* is equivalent to β^{AB} and so on.

Sheep exhibit the most complex example of β-globulin polymorphism found so far, although it is now known that β-globulin polymorphism in mammals is the rule rather than the exception.

I thank K. F. Mitchell for his technical assistance.

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Hageman Factor in Plasma Foreign Surface Reactions

PLASMA kinin[1] (originally named "pain-producing substance"[2]) is a pain-producing and smooth muscle-contracting polypeptide which can be released from human blood plasma in a number of ways, including contact with glass and some other surfaces. The mechanism of kinin release by contact has been resolved into two stages: in the first, 'contact factor' is formed from its precursor ('component *A*'); in the second 'contact factor' reacts with another constituent ('component *B*')[1,3].

Plasma can be freed of component *B* by rotating for 5 min. with 1/7–1/5 gm./ml. of glass ballotini (diameter 0·1 mm.) and then incubating in siliconed tubes for 2 hr. Such '*B*-depleted' plasma does not release any kinin on contact with glass but can still form 'contact factor' which will liberate the kinin when mixed with untreated plasma. Further exposure to 1 gm./ml. of ballotini for 30–60 min. exhausts the capacity of plasma to form the 'contact factor', presumably because its precursor (component *A*) has been used up[1,3].

'Contact factor' cannot be produced in plasma deficient in Hageman factor[4], which is also essential for the initiation of clotting *in vitro*[4,5]. On this ground and because of many other similarities with the changes involved in the inception of clotting, it was suggested that these two sets of phenomena are mediated by a common initial reaction[1,3].

In the present experiments it was found that although neither Hageman-deficient plasma nor plasma depleted of component *A* could form contact factor, a mixture of the two behaved like normal plasma. The mutal correction occurred only if the two plasmas were exposed to glass together, but not when they were exposed separately and mixed afterwards. It follows that component *A* is not identical with Hageman factor, and probably also that one of these components is active only when in actual contact with the surface.

The following observations indicate that Hageman factor becomes activated by adsorption on to the glass surface and that it does not return into solution in the active form as was previously thought. When glass was treated with normal plasma, it acquired the ability to activate fully Hageman-deficient plasma. This property persisted after washing with ten or more changes of saline at *p*H 7–8. Prior treatment of glass with Hageman-deficient plasma had no such effect. The adsorbed substance could be eluted at *p*H 10–11 and, after addition of sufficient hydrochloric acid to lower the *p*H to about 8, could be transferred on to fresh glass. At the same time the glass which was washed in the alkaline solution lost its ability to react with Hageman-deficient plasma, but it could still activate normal plasma. Since the addition of the eluate (without glass) to normal plasma did not lead to kinin release, it appears that the adsorbed component (presumably Hageman factor) reverts to its precursor state when removed from the glass surface.

Parallel observations were recorded on the behaviour of Hageman factor in blood coagulation, in this case plasma thromboplastin antecedent taking part instead of component *B* in the corresponding stage of the reaction[5]. All the evidence thus leads to the conclusion that release of plasma kinin and initiation of clotting are connected through surface-adsorbed Hageman factor. The kinetics of the initial stages of kinin release and coagulation can be appreciated better if we think of Hageman factor activating the glass surface rather than the other way round.

Since the similarities between the two sets of phenomena can now be explained on this basis it is no longer necessary to postulate another connexion between them, although this is by no means excluded. In previous publications[1,3] such a connexion was attributed to a common 'contact factor', which was implicitly defined as the first observable soluble product of the contact reaction. If this meaning is to be preserved then the precursor of 'contact factor' cannot be identified with Hageman factor but must be regarded rather as a substrate on which the latter acts. It is conceivable that there exist in plasma two or more 'contact factor' systems activated by the same initial reaction in which Hageman factor is the key component.

The present conclusions are supported by the studies of Bangham *et al.*[6], who showed that glass particles coated by plasma proteins exhibit marked changes in their electrophoretic mobility. Above *p*H 9 the mobility tends to revert to that of uncoated glass, probably due to desorption of the adsorbed proteins.

It is unlikely that Hageman factor is the only component of plasma which adheres to the glass, but it should be possible to make use of this property as a step towards its isolation.

The full details of this investigation will be published elsewhere.

I wish to thank Prof. C. A. Keele for his valuable advice, Dr. R. M. Hardisty for samples of plasma, and Mr. F. J. Haydon and Miss B. Austin for technical help.

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A Rapid Method for separating Glomeruli from Rabbit Kidney

In the course of investigations into the site at which renin is found in the kidney it became necessary quickly to separate glomeruli from other renal elements. Previous experiments on fat embolism had shown that in the kidney fat particles were restricted largely to glomeruli. It therefore seemed possible that if particles of the right size could be introduced into the renal circulation they would lodge in the glomeruli. This consideration, together with an early admiration for the experiment in which the function of the otocyst and otolith were demonstrated by inducing the crayfish (*Palinurus*) to use a particle of magnetic oxide of iron as an otolith, suggested that if the particles introduced into the renal circulation were magnetic it would be possible to separate the glomeruli with a magnet. This has been done. Since it can be done quickly and without much greater disturbance than is involved in mechanically disrupting the kidney, the method may be useful to others interested in locating enzymes in the kidney.

Heparin (1,000 units) is injected intravenously in a rabbit. Five minutes later the animal is killed. After death the abdomen is opened and the renal arteries cannulated, care being taken to avoid introducing air bubbles. The cannulæ are connected to an infusion apparatus containing a freshly prepared warm (37° C.) suspension of magnetic oxide of iron in 0·9 per cent sodium chloride. The infusion is allowed to run in under a pressure of 120 mm. mercury until about 100 ml. has flowed through each kidney and the rate has greatly slowed. The kidneys are then excised and taken to a laboratory at 4° C. at once. The magnetic oxide of iron was prepared by the method of Baudisch and Welo (1925) in which 2·6 gm. sodium hydroxide and 20 gm. potassium nitrate dissolved in about 100 ml. of water saturated with oxygen are poured into a solution of 9 gm. ferrous sulphate in about 100 ml. of water and the mixture brought to the boil. The precipitate of magnetic oxide of iron is now particulate and is washed about ten times with water by decantation. It is kept in 0·9 per cent sodium chloride until it is needed. Just before the rabbit is heparinized the iron oxide suspension is added to a freshly prepared filtered warm solution of 7 per cent gum acacia in 0·9 per cent sodium chloride, the concentration being about 50 mgm. dry oxide for 100 ml. solution.

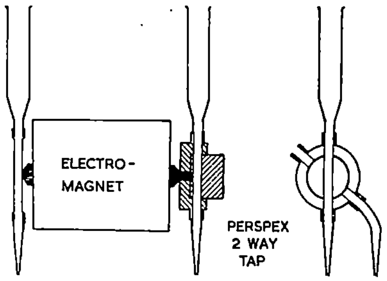

Fig. 1. Arrangement used for magnetic separation

The kidneys are cut into transverse sections about 2 mm. thick. The glomeruli should be visible as black specks, and cleared sections show that the iron particles are largely restricted to the glomeruli, though some medullary vessels contain them. The cortex is now cut off with a razor blade, the resulting fragments of cortex are pressed through a 150-mesh sieve and the mush emerging on the other side suspended in isotonic physiological salt solution containing 2 gm. dextrose and 4·5 gm. sucrose per litre[1]. Although in our work we have used this formula for physiological saline, Krebs's solution would for most purposes be preferable. The suspension is centrifuged slowly (800 r.p.m.). The deposit is resuspended in fresh saline solution and again centrifuged. The deposit, again suspended in saline solution, is now poured slowly through a tube, or system of tubes, which at one point lies close to the pole of an electro-magnet consisting of 10 lb. of 18 S.W.G. enamelled copper wire wound on a soft-iron core and connected to a 12-V. accumulator (Fig. 1). Attached to one pole of the magnet is a 'Perspex' two-way tap (Fig. 1, right). The first separation is made by running the suspension through one system of tubes, physiological saline succeeding the suspension to carry away non-magnetic particles. Afterwards the tap is turned, the magnet switched off and the magnetic fraction now adhering to the 'Perspex' tap in apposition to the magnet washed off through the second system of tubes with physiological saline. The separation, using this system, is repeated two or three times. The final purification is made by running suspensions through a vertical tube, of which the centre section consists of a thin-walled rubber tube touching the other pole of the electro-magnet. After washing the adherent magnetic fraction with physiological saline, this section of tubing is removed and the glomeruli washed out.

The magnetic and non-magnetic fractions so obtained are run past the magnet until examination under the microscope shows that all, or nearly all, the magnetic fraction consists of tissue containing iron, while the non-magnetic fraction contains none (Fig. 2). At this stage the magnetic fraction consists of glomeruli with or without attached fragments of

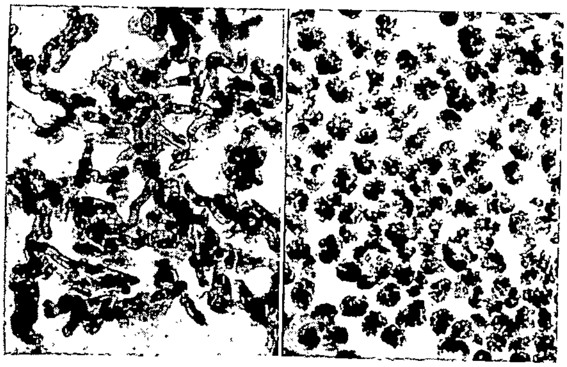

Fig. 2. Photographs (×80) of non-magnetic fraction on left and magnetic fraction on right. The magnetic fraction consists entirely of glomeruli containing iron oxide, some of the glomeruli having attached fragments. The non-magnetic fraction consists mainly of tubules, though connective and vascular tissue and a few fragments of glomeruli without iron are present

proximal tubules, macula densa and arterioles. By pouring this fraction through a 150-mesh sieve it may be separated into glomeruli without attachments, which pass through, and those with attachments, which remain on top. The non-magnetic fraction consists almost entirely of tubules, though there are often small fragments of glomeruli without iron as well as vascular and connective tissue.

The method was devised to locate renin, for which it has proved helpful. We have also used it successfully in the sheep and see no reason why it should not be applicable to other species. It is presented here in the hope that it may help those who are interested in the distribution of enzymes and other substances and who wish to decide whether they are found in glomeruli or tubules.

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Maintenance of Oligotrich Protozoa from the Sheep Rumen *in vitro*

HUNGATE[1,2] successfully cultivated ciliate oligotrich protozoa from the rumen of cattle; but Sugden[3] was unable to maintain protozoa from the sheep's rumen alive for more than fifteen days. This communication describes the successful maintenance of these protozoa from the rumen of a single hay-fed Clun Forest sheep.

The substrate consisted of 30 ml. quantities of autoclaved mineral salt solution to which was added: $Na_2S.9H_2O$ to a final concentration of 0·01 per cent; *c.* 15 mgm. finely ground dried grass (55° for 3 days); 15 mgm. rice starch, added as a suspension of known concentration in water; chloramphenicol to a final concentration of 50 µgm./ml. and 3·0 ml. prepared rumen fluid. The final volume was *c.* 35 ml. The mineral salt solution contained per 100 ml.; K_2HPO_4, 0·63 gm.; KH_2PO_4, 0·49 gm.; NaCl, 0·063 gm.; $MgSO_4.7H_2O$, 0·009 gm.; $CaCl_2.6H_2O$, 0·009 gm.; CH_3COONa, 0·075 gm. The rumen fluid was taken from the same sheep as the original inoculum and prepared by centrifuging fresh crude rumen contents to remove protozoa followed by filtration through Ford's 'Sterimat *CC*/01'. Tubes of completed medium were gassed vigorously with 95 per cent nitrogen + 5 per cent carbon dioxide for 3 min. and stoppered immediately.

The protozoa for inoculation were prepared from rumen contents taken 3–6 hr. after feeding. The crude material was strained through one layer of muslin, centrifuged for 2 min. at 500*g* and the pellet washed once on the centrifuge with the salt solution containing 0·01 per cent $Na_2S.9H_2O$. The protozoa were then suspended in the medium at 2–4 times their concentration in the rumen and the tubes gassed for 15 sec., stoppered immediately and incubated at 38°. In the initial stages of each experiment, it was beneficial to add 15 mgm. $MgCO_3$ levis to each tube, but when the organisms were growing uniformly this could be omitted.

To maintain the organisms alive for more than 36 hr., it was necessary each day to centrifuge down the protozoa at 500*g* for 2 min., remove the supernatant and replace this by fresh complete medium. To divide a culture, the protozoa suspended in the fresh medium were diluted with an equal volume of complete medium and the whole placed in two centrifuge tubes which were then gassed and sealed. The number of organisms present was estimated by diluting a sample of the culture eleven times with 0·02 *M* iodine in potassium iodide and counting the protozoa present in 0·1 ml.

After the initial inoculation, the total number of organisms decreased and all the holotrich protozoa died before the fifth day. Thereafter, the number of oligotrich protozoa remained constant or slowly decreased for 2–8 weeks after which the numbers increased. When the number of organisms reached 30,000 per ml. the culture was divided into fresh medium. The numbers increased until it was possible to divide the culture into fresh medium every 2–4 days, and at the time of writing, the maximum number of such divisions was 40. A typical growth curve from this last period is shown in Fig. 1.

The predominant types of organisms were morphologically similar to *Entodinium caudatum* and *E. longinucleatum* as described by Bhatia[4], but some similar to *Metadinium medium* and *Entodinium simplex* were also present, especially when the time between successive divisions exceeded 10 days.

Under these conditions of growth, the omission from the medium of the rice starch or dried grass usually resulted in the death of the protozoa in less than

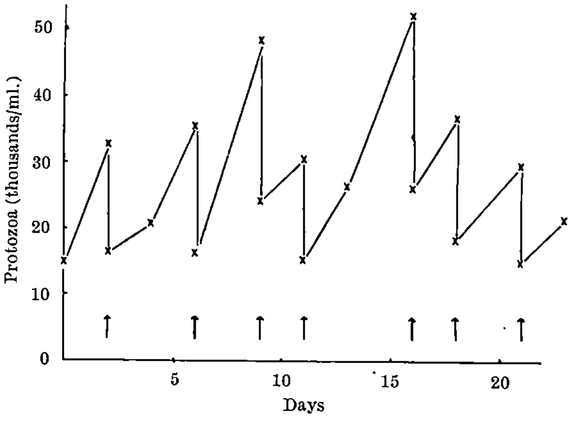

Fig. 1. Growth of oligotrich protozoa four months after the initial inoculation. The arrows indicate the times at which the culture was divided into an equal volume of fresh medium

3 or 10 days respectively, although, in the latter case, small numbers occasionally persisted for longer periods. When chloramphenicol or rumen fluid were omitted, the organisms grew normally for 3–4 days, but afterwards the numbers dropped to, and remained constant at, a low level. Sterilization of the dry rice starch at 140° C. for 1 hr. and heating the dry grass at 100° C. for 2 hr. prior to addition to the medium did not affect the growth-rate. No organisms were found after one week in uninoculated control tubes.

Further experiments are at present in progress in an attempt to increase the growth-rate of the organisms and to isolate a single strain of protozoan.

I wish to thank Miss C. M. Tebbutt for her expert technical assistance.

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Sodium Uptake by the Crayfish

It is now well established that many freshwater animals can absorb sodium and chloride ions from very dilute solutions. This was first demonstrated by Krogh[1] in animals which had been previously depleted of salt; since then, it has been shown by the use of radioactive tracers that in the axolotl[2], in the frog[3] and in the crab, *Eriocheir*[4], ion absorption occurs continuously in the normal animal as part of the mechanism for the maintenance of salt balance. Salt balance results when the rate of salt uptake equals the total loss of salt through the integument and by way of the excretory fluid, but little is known of the extent to which the uptake rate is regulated by the animal or of the internal or external factors upon which the uptake rate normally depends.

An attempt has been made to throw some light on the mechanism of the regulation of sodium uptake in the freshwater crayfish, *Astacus pallipes*. In particular, the influence of variations in the internal sodium content and of the external sodium concentration on the rate of uptake, has been studied.

To measure sodium uptake, a crayfish weighing about 10 gm. was placed in 250 ml. of water containing a known concentration of sodium chloride in the range, 0–1 m*M*/l. A proportion of the added sodium was present as sodium-24 and the radioactivity of the solution was measured initially and then at frequent intervals after the start of the experiment. No experiment proceeded long enough for back-diffusion of radiosodium to have a significant effect on the measured uptake rate or for large changes in the internal or external sodium concentrations to occur. The rate of uptake of sodium (the sodium influx) was calculated from the rate of loss of activity from the outside solution, after correction for decay. Net uptake was also measured from changes in the external sodium concentration.

The normal uptake rate for animals in 0·3 m*M*/l. sodium chloride solution (the sodium concentration of Newcastle tap-water) was about 1·5 μ*M*/hr./10 gm. body-weight (Table 1). Loss of sodium from the animal caused a gradual increase in the uptake rate until a maximum rate for a given external concentration was reached (Table 1). The maximum rate was 4–5 times the normal value. Conversely, sodium uptake was depressed by an increase in the internal sodium. When the uptake mechanism was stimulated the animal could maintain itself in sodium balance at a much lower external sodium concentration than before (Table 1). At the maximum uptake rate the equilibrium concentration was only about one-tenth of the normal tap-water concentration. To increase the uptake rate from normal to the maximum required the loss of about 6–8 per cent of the internal sodium. Significant changes in the uptake rate occurred after changes of only 1–2 per cent of the internal sodium content.

Table 1. Uptake Rates in the Crayfish, measured with Sodium-24

Specimen No.	Uptake rate from 0·3 m*M* NaCl sol. in μmole/hr./10 gm. body-weight Normal rate	Maximum rate	Lowest equilibrium concentration m*M* Na
1	1·1	5·3	0·03
2	1·4	4·9	0·03
3	1·7	5·7	0·09
4	1·8	7·3	—
5	1·4	5·3	0·02
6	1·5	7·8	0·04

The low equilibrium concentration achieved when the uptake rate is maximal is a direct consequence of the fact that the uptake rate, itself, depends on the external sodium concentration. The relationship between these for a typical individual is shown in Fig. 1. This shows the uptake rates for the animal in equilibrium with an external concentration of 0·2 m*M*/l. sodium (open circles) and also the increased uptake rates of the animal in equilibrium with an outside concentration of 0·03 m*M*/l. sodium (full circles). The relation between the uptake rate and the external sodium concentration is a non-linear one but appears to conform to a relation of the Michaelis–Menten type, as might be expected if the sodium ions are transported by a carrier system which becomes saturated at higher sodium concentrations. The continuous line in Fig. 1 is derived from the expression: $M = Kc/(K_m + c)$, where M is the uptake rate and c the external sodium concentration. The constants, K and K_m have been given arbitrarily chosen values of 7 and 0·25 respectively. The very low concentration at which half-saturation occurs is noteworthy and indicates a very high affinity of the carrier for sodium ions.

These studies show that sodium uptake in the crayfish takes place by a mechanism which is highly regulated and well adapted to maintain the animal

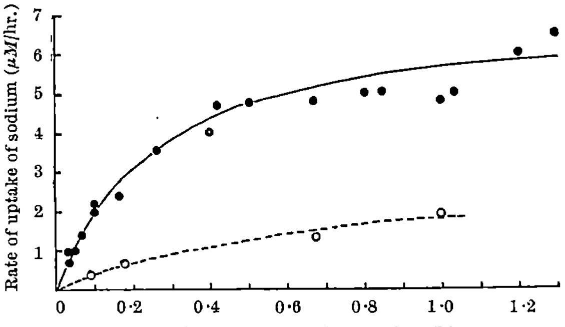

Fig. 1

in sodium balance. Although the rate of uptake is sensitive to changes in the external sodium concentration (at the concentrations found in tap-water) any resulting change in the internal sodium content brings about a change in the uptake rate in the opposite direction and a self-balancing system results.

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Prevention of Allergic Encephalomyelitis by Prior Injection of Adjuvants

In a recent article[1] Svet-Moldavskaya and Svet-Moldavsky have reported that repeated injections of immature rabbit brain into guinea pigs prevented the development of allergic encephalomyelitis when the same animals were given active (adult rabbit brain) injections at a later date. From this observation they have proposed the existence in brain of two factors, one of which is responsible for the development of encephalomyelitis, the other for the development of acquired resistance against it.

The acquired resistance to allergic encephalomyelitis described by these authors has been observed previously, but it was not ascribed to any factor in brain itself. Lumsden first described it in 1949 [2] and rightly attributed protective action of inactive brain fractions to the adjuvant itself. He states: "The results . . . seem to suggest that the mere injection of 'adjuvants' alone may in some way produce immunity to the encephalitogenic factor in brain tissue".

Results obtained in our laboratory have verified Lumsden's assumption (Table 1). The animals in experiment *A* were given as their first injection the complete vaccine, as controls for subsequent tests on protection. Since they all succumbed to the disease, no challenge injection was possible. In experiment *B* three different initial injections were given, each containing one of the ingredients of the complete vaccine (oil/aquaphor, bovine cord fraction, and killed tubercle bacillus). The complete vaccine was injected thirty days after the initial injection. Of these three, the killed tubercle bacillus was the only one showing any protective effect. From experiment *C* it is apparent that the oil–aquaphor component, inactive in suppressing subsequent disease when injected alone, markedly enhances the protective effect of the tubercle bacillus. The nervous tissue fraction in oil/aquaphor also appeared to have a slight protective effect, but the difference is not significant at the 5 per cent level. Killed tubercle bacillus and nerve fraction combined may be somewhat more effective than tubercle bacillus alone, but this is doubtful.

Histological examination of the inoculation sites of those animals receiving a primary protective injection (killed tubercle bacilli in oil-adjuvant mixture) revealed almost complete suppression of epithelioid cell reaction and encapsulation of the injection material by neutrophilic leucocytes and fibrous tissue, compatible with the Koch reaction.

Table 1. PROTECTION AGAINST ENCEPHALOMYELITIS BY PRIOR INJECTION WITH INCOMPLETE VACCINE

Expt.	Composition of first vaccine*			Disease index† (mean ± S.E.)
	Oil + aquaphor (ml.)	Bovine cord fraction (mgm.)	Tubercle bacilli (mgm.)	
A	0·08	0·02	0·25	7·9 ± 1·2‡
	0·08	0·02	0·25	8·4 ± 0·9‡
	0·08	0·02	0·1	7·1 ± 1·1‡
B	0·08	—	—	9·4 ± 0·2
	—	0·02	—	7·6 ± 1·2
	—	—	0·25	3·3 ± 1·3
C	0·08	0·02	—	5·7 ± 1·0
	—	0·02	0·25	1·1 ± 0·3
	—	0·02	0·25	0·1 ± 0·03§
	—	0·02	0·1	6·0 ± 1·8
	0·08	—	0·5	0 ± 0
	0·08	—	0·25	0·2 ± 0·1
	0·08	—	0·1	0 ± 0
	0·08	—	0·01	1·2 ± 0·7

* Given 30 days prior to complete vaccine.

† Measure of severity of disease reaction based on clinical and histological results. 0 = no reaction; 10 = maximal reaction in all animals on test (ref. 3).

‡ Complete injection, no challenge possible.

§ No challenge given, killed at 60 days.

Protection against 'allergic' encephalomyelitis is complex and may be produced in many different ways[4]. It can be produced by a single injection of a saline suspension of brain in neonatal or immature animals (see Paterson[5], also discussion by Waksman) by repeated injections of brain in adult animals (Ferraro, Condie[5]), or by passive transfer of serum from encephalitic animals (Florey[5]) and by other techniques, such as reported here.

It should be noted that in the present experiments only a single injection of incomplete vaccine was given one month before challenge, that the most important protective factor under these conditions is in the tubercle bacillus, and that this factor is markedly potentiated by the oil–aquaphor suspending medium. The data do not preclude the possibility that repeated injections of brain in oil–aquaphor might produce significant protection, but this experiment has not yet been performed. Whether there would be any difference between immature and mature brain in such an experiment also remains to be determined. However, since the results of Svet-Moldavskaya and Svet-Moldavsky can be attributed to the presence of tubercle bacillus in the original injection, their conclusions regarding a protective factor in immature brain are unjustified until the latter is tested in the absence of tubercle bacillus.

Marian W. Kies

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Ellsworth C. Alvord, jun.

Department of Pathology and
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Baylor University College of Medicine,
Houston, Texas.

Aug. 7.

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Movements of Lugworms

A RECENT review of the hydrostatic skeleton in invertebrates by Chapman[1] includes the following sentence about *Arenicola*: "Wells (1954) has shown that the three anterior septa are connected with the retention of the proboscis against the normal resting or tonus pressure maintained by the body-wall in the cœlom, which would otherwise be sufficient to cause protrusion of the proboscis". This is untrue; I did not show, or claim to show, what he ascribes to me. The paper to which he refers[2] contains an analysis of the working of the very intricate proboscis mechanism. The first of the three anterior septa is differentiated into several parts and actively assists both the extrusion and the withdrawal of the proboscis, the details varying somewhat with the species; the extent of its responsibility for keeping the resting proboscis in position is unknown. Neither of the other two anterior septa has anything to do with the movements or position of the proboscis.

In the same review Chapman writes that in errant polychætes "the oblique muscles run from a lateral position to a point below the nerve cord" but in *Arenicola* "no oblique muscles are present", that "the lugworm cannot crawl", and that eversion of the proboscis is assisted by "a simple contraction of the posterior end of the lugworm". In fact, of course, the oblique muscles of *Arenicola* are numerous and conspicuous in dissections[3], the worms crawl actively in their burrows, in glass tubes or on the surface of the sand[4], and, as anyone who has watched a vigorously burrowing lugworm will agree, the description of the movements of its hinder part as simple is wide of the mark. He appears to regard the parapodial musculature as largely or entirely derived from the circular muscle layer of the body wall; in fact, as one would expect on functional grounds, the chief parapodial muscles run longitudinally and are derived from the longitudinal layer[5]. It is regrettable that such inexact statements have been put into circulation when accurate information about the movements of lugworms, and the structures which bring them about, was already available.

G. P. WELLS

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London, W.C.1. Aug. 1.

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Striations of Skeletal Muscle

IT seems to have been generally assumed that the structure of myofibrils in skeletal, or striated, muscle is fundamentally similar in all the vertebrate classes, and, in addition, observations on invertebrates, particularly insects, have been widely applied to the muscles of vertebrates. In fact, much of the detailed morphological description of striations of mammalian muscle in histological text-books appears to be based on work on insects, as can be seen by reference to Schafer's well-known text-book[1], or to Cowdry's work on special cytology[2].

This assumption of structural uniformity in all animals is supported by the appearance as seen by using crossed 'Polaroid' glasses, or crossed Nicol prisms, and by staining with Heidenhain's iron hæmatoxylin method.

However, use of a wider range of staining methods, including basic dyes, presents evidence which suggests that species differences in the structure of myofibrils occur, as shown by the differing relation of bands stained to birefringence in different animal types when using the same staining technique. This observation raises the question as to how much of the physiological and biochemical data obtained on other forms is directly applicable to mammalian, and in particular to human, muscle.

Dempsey, Wislocki and Singer[3] (who worked with monkeys, rats and a newt, *Triturus viridescens*) claimed that basic dyes stained the anisotropic (or doubly refractile) segments, and that acidic dyes stained the isotropic (singly refractile) segments. Neither of these statements appears to be of general application. I have previously illustrated[4] the appearances of human muscle as stained by the acidic dye fast green *F.C.F.* On that occasion, relying on the assumption of uniformity and the results of Dempsey, Wislocki and Singer, I misinterpreted the significance of the bands stained by this dye. In man, and other animals so far examined, it is not the isotropic but the anisotropic segments which are stained by acidic dyes.

These observations indicate that in considering the structure of myofibrils more attention should be paid to the possibility of species difference.

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Effect of Chloramphenicol on a Fungus

DURING an investigation of the formation of extracellular nitrogen compounds by fungi[1], the effect of chloramphenicol on this process was tested, since in bacteria chloramphenicol is known to interfere with protein synthesis[2] [3] and with the synthesis of enzymes concerned with amino-acid metabolism[4], although it has no effect on the growth of many fungi[5].

A strain of *Scopulariopsis brevicaulis* (Sacc.) Bainier was grown in surface culture in a synthetic glucose–nitrate liquid medium as used previously[1], to which a trace metal supplement containing iron, copper, zinc, manganese and molybdenum was added. Chloramphenicol was added to some of the flasks at a final concentration of 20 or 50 μgm./ml. In the control flasks growth of the fungus was rapid, all the nitrate was assimilated in 6–7 days, and the mean dry weight of mycelium after 20 days was 180 mgm. per flask. The extracellular nitrogen formed represented 16–20 per cent of the nitrogen supplied. In the presence of chloramphenicol, however, growth of fungus was very slow and nitrate did not finally disappear from the medium until 20–40 days after inoculation, when the dry weight of mycelium was

100–120 mgm. per flask. The extracellular nitrogen formed represented 30–35 per cent of the nitrogen supplied. There was no difference in effect between the two levels of chloramphenicol.

This very marked effect of chloramphenicol on the metabolism of *S. brevicaulis* was only found with nitrate as nitrogen source. When nitrate was replaced by ammonia, nitrite, or a mixture of amino-acids, chloramphenicol was without effect and the fungus behaved exactly as in the control flasks. The effect of chloramphenicol in nitrate medium was also completely removed merely by growing the fungus in submerged conditions with vigorous shaking.

The inhibiting effect of chloramphenicol on the fungus in nitrate medium in static culture could not be overcome by the addition of increased trace elements (up to ten times the normal level), or by the addition of yeast extract. It could, however, be overcome by an unknown factor present in commercial glucose and removable therefrom by a cation exchange resin. There was no evidence that the nitrate reductase system was inhibited in the presence of chloramphenicol.

When several other fungi (*Penicillium griseofulvum* Dierckx, *Botrytis allii* Munn., *Aspergillus niger* v. Tieghem, *Fusarium graminearum* Schwabe) were tested in the same conditions as *S. brevicaulis* their rate of growth and nitrate assimilation, and the extent to which they formed extracellular nitrogen compounds, were completely unaffected by chloramphenicol.

No explanation can be given of this effect of chloramphenicol upon *S. brevicaulis* alone among many fungi tested and manifest only in nitrate medium in conditions of surface culture. It seems worth recording if only as an example of that biological specificity which is often so puzzling.

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D. A. TERRY

Imperial Chemical Industries, Ltd.,
Akers Research Laboratories,
Welwyn, Herts. Aug. 26.

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[1] Morton, A. G., and Broadbent, D., *J. Gen. Microbiol.*, **12**, 248 (1955).

[2] Gale, E. F., and Folkes, J. F., *Biochem. J.*, **53**, 493 (1953).

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Removal of Osmic Acid Stains

IN the current literature on electron microscopical methods[1] many weaknesses of osmic acid as a fixing agent have been carefully analysed and appropriate safety methods, which would reduce if not entirely eliminate these, have been recommended. No useful advice appears to have been given, however, on the proper cleaning of glass and other utensils after they have become stained with osmic acid or on the removal of osmic acid precipitates, and consequently some wastage of this not inexpensive material at present seems to be accepted as inevitable.

Many years ago, one of us[2], working on an extensive series of peripheral nervous tissue material treated with osmic acid, found bleaching of the sections in 3 per cent hydrogen peroxide extremely useful as a preliminary to the application of other staining methods. Though no special mention was made of this, as it appeared a logical step to take, at that time all glassware and other apparatus contaminated with precipitated osmic acid was washed as a matter of routine with hydrogen peroxide, the strength of the solution depending on the heaviness of the soiling, or the speed required for the finishing of the cleaning process.

With the advent of electron microscopy, osmic acid is again used extensively, and the need for efficient cleaning of glassware and apparatus has reappeared. Hydrogen peroxide was again found fully satisfactory for this purpose and it is used by us as a routine procedure.

It is well known that osmic acid renders cells and tissues difficult to stain by customary methods. Presumably because of this difficulty most workers, in order to achieve the necessary tissue orientation in electron microscopy, use the phase-contrast microscope for this purpose on parallel, thicker sections, though the information thus obtained is not as good as that provided by stained preparations.

At present we are studying systematically the staining properties of sections fixed with osmic acid and embedded in methacrylate after bleaching them in hydrogen peroxide. It is already apparent that most staining methods are applicable to these sections with reasonable success and without any major modification in the procedure.

Details of this work will be published elsewhere.

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Department of Anatomy,
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[1] Porter, K. R., Claude, A., and Fullam, E., *J. Exp. Med.*, **81**, 233 (1945). Palade, G. E., *ibid.*, **95**, 285 (1952). Rhodin, J., *Pub. Karolinska Inst.*, Stockholm (1954).

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An Apparently Simple Case of Population Control

IT is not usually possible to discover what factors control any particular population, that is, what factors act more strongly against the population as it increases and so tend to keep its numbers constant. In a small planted beech wood just west of Marlborough (Nat. Grid Ref. *SU* 175680) there is a population of the common snail *Helix aspersa* which seems to be controlled in a very simple manner. The trees have small buttresses at their bases, leaving narrow caves between, and in the winter the snails crawl into the caves to hibernate. When I visited the wood on January 21, 1954, with Drs. S. M. McGee Russell and P. M. Sheppard, we found no *aspersa* were hibernating near the outsides of the caves: all were deeply inside. When Dr. Sheppard visited the copse in the previous autumn there were many snails not fully in the crevices, and he tells me that there were far fewer predated shells then than we saw in January. It was as if all snails which were hibernating in a position in which a predator could reach them had been eaten, while those in inaccessible positions survived. As these inaccessible positions would not change greatly from year to year, this system would keep the population at a constant size in the same way that an overflow pipe keeps water in a tank at constant depth. Squirrels were probably the predator concerned.

This colony is unusual not only in its system of control. The snails were more markedly banded than garden snails, and most were immature. By using sticks we managed to secure 134 live snails of which only 30 were adult.

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Oxford. Aug. 1.

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, October 20

Society of Chemical Industry, Pesticides Group (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Papers on "Preservation of Timber".

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "The Presentation of Electrical Science in Schools".

Society of Instrument Technology, Data Processing Section (at Manson House, Portland Place, London, W.1), at 6 p.m.—Mr. G. P. Tonkin and Mr. J. B. Bownas: "A Simple Data Read-Out System".

Institute of Metal Finishing (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. W. J. Campbell: "Recent Developments in Hard Anodizing".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. Tom Harrisson: "Exploration in Changing Borneo".

Tuesday, October 21

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. D. R. Wilkie: "Man-Powered Flight".*

Institution of Chemical Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. R. L. Brown and Mr. J. C. Richards: "Exploratory Study of the Flow of Granules through Apertures".

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. L. Brillouin: "Information Theory and Its Applications to Fundamental Problems in Physics".* (First of five special university lectures. Further lectures on October 23, 24, 27 and 29.)

Royal Institute of Chemistry, London Section (joint meeting with the South-East Essex Technical College Scientific Society, at the South-East Essex Technical College, Longbridge Road, Dagenham), at 7 p.m.—Dr. A. E. Martin: "Infra-Red Analysers and Spectrometers".

Wednesday, October 22

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Discussion on "Technical Difficulties Experienced by Industry in Complying with the Clean Air Act and Regulations" opened by Mr. H. E. Hopthrow, C.B.E.*

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. G. Millington: "Random Thoughts of a Propagation Engineer" (Chairman's Address).

Challenger Society (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 5.45 p.m.—Dr. Brian P. Boden and Dr. Elizabeth M. Kampa: "The Deep Scattering Layer".

Institution of Mechanical Engineers, Education Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Recent Developments in Engineering Education in the United States of America".

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. D. J. Godfrey: "Cavitation Damage".

Oil and Colour Chemists' Association, London Section (joint meeting with the British Society of Rheology, at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 7 p.m.—Mr. C. C. Mell: "Rheological Behaviour of Paint Systems at Low Shearing Rates".

Radar and Electronics Association (at the Royal Society of Arts, John Adam Street, London, W.C.2), at 7 p.m.—Major P. L. Teed: "Fatigue of Metals".

British Psychological Society, Medical Section (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 8.30 p.m.—Dr. Marie Jahoda: "Current Concepts of Mental Health".

Thursday, October 23

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. Marion A. Watson: "Recent Discoveries about Aphid and Hopper Transmitted Viruses"; Dr. A. F. Posnette: "Leafhopper Transmission of Green Petal and other Viruses in Strawberry"; Prof. L. J. Audus: "A Botanist in California".

Royal Anthropological Institute of Great Britain and Ireland (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Miss Barbara E. Ward: "Floating Villages: Chinese Fishermen in Hong Kong".

Friday, October 24

British Psychological Society, Occupational Psychology Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mrs. M. Bucklow: "Psychological Work in the Commonwealth Bank of Australia".

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 4 p.m.—Symposium on "Engine Noise and Noise Suppression".

University of London (at Senate House, London, W.C.1), at 5.30 p.m.—Prof. Paul Veyret (Grenoble): "Modern Theories of the Structure of the Alps".* (First of three special university lectures. Further lectures on October 27 and 29.)

Society of Dyers and Colourists, London Section (at the Waldorf Hotel, Aldwych, London, W.C.2), at 7 p.m.—Mr. A. Lucas: "Colour in Art" (Sixth London Lecture).

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Lawrence Bragg, F.R.S.: "Treasures in the Collections of Apparatus at the Royal Institution".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer (registered pharmaceutical chemist, graduate in pharmacy or science, and preferably with research experience) in Pharmaceutical Chemistry in the Department of Pharmacy and Biology—The Registrar, College of Technology, Birmingham 4, quoting "C" (October 23).

Senior Lecturer (with a degree in electrical engineering and Corporate Member of the Institution of Electrical Engineers) in the Department of Electrical Engineering—The Registrar, Hatfield Technical College, Hatfield, Herts (October 27).

Assistant (science graduate, preferably with qualifications in physiology or biochemistry, or both) in Clinical Chemistry—The Secretary, The University, Aberdeen (October 31).

National Coal Board Postdoctoral Fellow in Physical Chemistry, for research work in connexion with the study of solids by a number of techniques such as mass spectroscopy—The Registrar, The University, Edgbaston, Birmingham 15 (October 31).

Temporary Lecturer (qualified in applied mathematics) in Mathematics—The Registrar, University College of North Staffordshire, Keele (October 31).

Research Assistant, for work on the structure of crystalline proteins using X-rays and electronic computers—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (November 1).

Meteorological Officers (with either (*a*) a first- or second-class honours degree (or equivalent) in physics or mathematical physics or mathematics or engineering or (*b*) a degree (or equivalent) in meteorology) in the Irish Meteorological Service—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin, Ireland (November 6).

Experimental Officer-Horticulturist (with a university degree in agricultural science or equivalent training in horticulture, and also practice on a large commercial or Government establishment, university or other research station) at the Irrigation Research Station, C.S.I.R.O., Griffith, N.S.W., Australia, for work in connexion with the layout of crop experiments on fruit, pastures and vegetables and for detailed work on plants under close environmental control—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting appointment No. 500/100 (November 8).

Chair of Geography in the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 15).

Lecturer (preferably with postgraduate experience in biochemistry) in Animal Nutrition in the Department of Animal Husbandry and Veterinary Hygiene, to undertake teaching and research—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (November 15).

Senior Lecturer or Lecturer in Mathematics at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 15).

Lecturer or Assistant Lecturer in Physical or Inorganic Chemistry at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 25).

Chance Chair of Mechanical Engineering—The Registrar, The University, Birmingham 15 (November 30).

Lecturer in Physics at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

Lecturer or Assistant Lecturer in Zoology at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 30).

Lecturer in Aeronautical Engineering—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

Lecturer in Physics—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

Lecturer (with a degree in chemical engineering or metallurgy, some industrial or research experience, and the ability to teach the engineering aspects of extraction metallurgy, including fluid mechanics and heat transfer) in the Metallurgy Department—Prof. F. D. Richardson, Metallurgy Department, Imperial College of Science and Technology, London, S.W.7.

Medical Laboratory Technician (qualified male or female) in the National Blood Transfusion Service—The Administrative Officer, Regional Blood Transfusion Centre, Crescent Drive, Brentwood.

Physics Master, to take the subject to scholarship level—The Headmaster, St. Albans School, Abbey Gateway, St. Albans.

Research Assistant in the Pathology Department, for work involving the application of X-ray methods to the study of bone structure—The Secretary, Pathology Department, Institute of Orthopædics, 234 Great Portland Street, London, W.1.

RESEARCH ASSISTANT (with a mechanical engineering or physics degree with a strong mathematical ability), to carry out theoretical and experimental work in a plastic-elastic body—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18.

SENIOR CLINICAL PSYCHOLOGIST, to organize and maintain a full psychological service for the hospital and its associated out-patients clinics—The Group Secretary, Cherry Knowle Hospital, Ryhope, near Sunderland.

ZOOLOGIST (graduate in zoology of a British university) at the Dove Marine Laboratory—The Registrar, King's College, Newcastle-upon-Tyne.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Annual Report of the Yorkshire Philosophical Society for the year 1957. Pp. 13. (York: Yorkshire Philosophical Society, 1958.) [138

Department of Scientific and Industrial Research. Hydraulics Research 1957: The Report of the Hydraulics Research Board with the Report of the Director of Hydraulics Research. Pp. v+69+8 plates. (London: H.M. Stationery Office, 1958.) 5*s.* 6*d.* net. [138

B.B.C. Television: a British Engineering Achievement. Pp. 64. (London: British Broadcasting Corporation, 1958.) 2*s.* 6*d.* [138

Falkland Islands Dependencies Survey. Scientific Reports. No. 18: The Breeding Behaviour and Reproductive Cycle of the Weddell Seal (*Leptonychotes weddelli* Lesson). By A. W. Mansfield. Pp. i+41+6 plates. 20*s.* net. No. 20: The Petrology of Graham Land. 3: Metamorphic Rocks of the Trinity Peninsula Series. By Dr. R. J. Adie. Pp. i+26+2 plates. 13*s.* 6*d.* net. No. 21: Upper Jurassic and Cretaceous Ammonite Faunas of Alexander Land and Graham Land. By Dr. M. K. Howarth. Pp. i+16+5 plates. 16*s.* 6*d.* net. No. 22: The Introduced Reindeer of South Georgia. By W. Nigel Bonner. Pp. i+8+3 plates. 7*s.* net. (London: H.M. Stationery Office, 1958. Published for the Colonial Office.) [138

Northampton College of Advanced Technology, London. Prospectus of Part-Time (Day and Evening) Courses in Engineering, Applied Mathematics, Applied Physics and Pure and Applied Chemistry, Session 1958–59. Pp. 40. (London: Northampton College of Advanced Technology, 1958.) [158

Proceedings of the Royal Institution of Great Britain, Vol. 37, Part 1, No. 165, containing accounts of the Friday Evening Discourses and other Meetings. Pp. 119. Published three times a year. (London: Royal Institution of Great Britain, 1958.) 8*s.* 6*d.* each part or 21*s.* per annum. [158

Report on a Brief Survey of the Charollais Breed: Pedigree and Cross Bred. By Craig Wheaton Smith. Pp. 37. (Ilminster: Horlicks Farms and Dairies, Ltd., 1958.) [158

Building Research Station Digest, No. 113 (August, 1958): The Costs of Mechanical Plant. Pp. 6. (London: H.M. Stationery Office, 1958.) 3*d.* [198

Medical Research Council. Statement on the Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. Pp. 15. (Cmnd. 508.) (London: H.M. Stationery Office, 1958.) 1*s.* net. [198

Department of Scientific and Industrial Research. Road Research Laboratory. Road Research Technical Paper No. 41: Field Studies of the Movement of Soil Moisture. By W. P. M. Black, D. Croney and J. C. Jacobs. Pp. vi+74. 6*s.* net. Road Note No. 5: Types of Road Surfacing and Maintenance Using Tar or Asphaltic Bitumen. Pp. iv+30. 3*s.* net. (London: H.M. Stationery Office, 1958.) [198

The Chemical Society. Annual Reports on the Progress of Chemistry for 1957, Vol. 54. Pp. xx+445. (London: The Chemical Society, 1958.) 40*s.* [198

Rothamsted Experimental Station. (Lawes Agricultural Trust.) Report for 1957 (with 50-Year Index, 1908–57). Pp. 316. (Harpenden: Rothamsted Experimental Station, 1958.) [198

Ciba (A.R.L.), Ltd. Technical Notes, No. 188 (August, 1958): High-Temperature Adhesives—Developments in Metal-to-Metal Bonding for Conditions of High-Speed Flight. Pp. 8. (Duxford: Ciba (A.R.L.), Ltd., 1958.) [198

Ministry of Supply. Reports on Plastics in the Tropics. 8: Asbestos Filled Phenolic Resin. Pp. 18. (London: H.M. Stationery Office, 1958.) 4*s.* net. [218

British National Formulary, 1957. First Amendment, 1958. Pp. 11. (London: British Medical Association and The Pharmaceutical Press, 1958.) 8*d.* [228

Journal of the Institute of Wood Science, No. 1 (March, 1958). Pp. i+64. (London: The Institute of Wood Science Limited, 1958.) 15*s.* [228

Other Countries

Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. (General Assembly—Official Records: Thirteenth Session, Supplement No. 17 (A/3838.) Pp. iii+228. (New York: United Nations; London: H.M. Stationery Office, 1958.) 2.50 dollars; 18*s.*; 10.50 Swiss francs. [78

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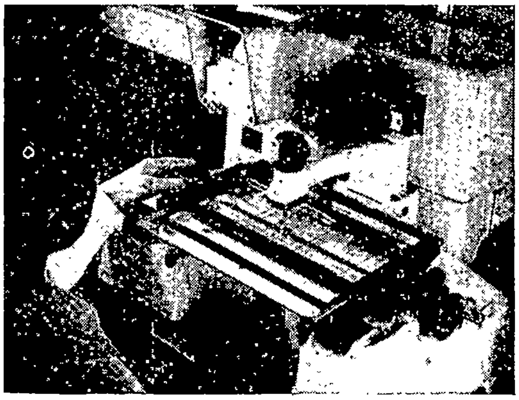

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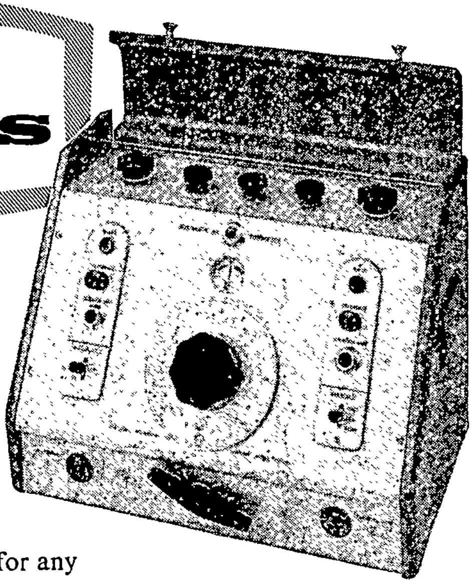

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SCIENTIFIC AND INDUSTRIAL RESEARCH IN GOVERNMENT DEPARTMENTS

IN its fifth report for the Session 1957–58* the Select Committee on Estimates considers the work of the Department of Scientific and Industrial Research. It is, however, limited to the work carried out directly by the Department through its fourteen experimental establishments: no comment is offered on the Department's work in relation to the universities, although this was considered in evidence submitted to the Committee. Moreover, apart from the single recommendation that the admissible reasons for refusing applications for membership of a research association should be explicitly stated in the terms of grant, and that the councils of the research associations should be required to furnish a list annually of the applications which they have rejected, with reasons, the work of the research associations is likewise only noted in evidence. Indeed, the Select Committee professes itself to be satisfied, in general, with the working of the research association scheme. Its report therefore deals solely with the organization and administration of the Department from the point of view of the Council's expenditure of the appropriate vote, and is thus in fact concerned with the sum of £5,775,587 gross expended on the fourteen experimental establishments out of the Department's gross estimate for 1958–59 of £10,472,993, though its criticisms and comments inevitably include also the headquarters expenditure of £537,206.

It will be seen from the foregoing alone that the Select Committee does not attempt to assess the place of the Department in Britain's general organization for research and development. The lacuna left two years and more ago by the Jephcott Committee remains unfilled, and although the Select Committee on Estimates makes a number of sensible suggestions, these might have been expected to have come from the Advisory Council on Scientific Policy. Such reference to the Advisory Council as is made in this report, which touches so closely on the responsibilities of both the Advisory Council and the Lord President of the Council, seems to endorse Sir Hugh Beaver's strong criticisms early this year. Furthermore, it is surprising that the work of the Department should have been submitted to a searching examination so soon after the report of the Jephcott Committee and the subsequent re-organization of the Department.

It is not that the Department comes badly out of this review. On the contrary, the Select Committee on Estimates recognizes that the new Executive Council of the Department is already engaged in a full-scale review of the work of all its establishments and has begun to re-shape and re-formulate policy. Indeed, it admits that many criticisms which might have been levelled against the Department's general organization as lately as November 1957, when the present inquiry began, had been rendered out of date by July 1958. Specifically it wholeheartedly welcomes the initiative of the Council in undertaking its present review and in establishing a policy of continuous reviews as likely to facilitate proper timing in terminating a piece of research—an operation as important as timing its institution and possibly more difficult as well as less frequently practised.

Apart from this general comment, the Estimates Committee's remarks relate to the relations of the Department with other government departments and with industry, and it is the other departments that incur the gravamen of its criticism. Four of the Department's experimental establishments differ from the other ten in that they work mainly for one particular government department, and of these four, the Road Research Laboratory was studied in some detail. Apart from its work for the Colonial Office, the Laboratory's work is principally on behalf of the Ministry of Transport and Civil Aviation, and although the Committee was satisfied with the liaison between the two departments, it comments trenchantly that contracts for road construction are only very exceptionally shown to the Laboratory. Without seeing the actual prices quoted, the Committee points out, the Laboratory's experts can scarcely be satisfied that the new practices they have recommended are properly understood and any financial savings made possible by these practices are in fact being achieved, nor can the Laboratory be sure that their recommendations are used unless regular reports are made to them about costs of construction and subsequent performance. Accordingly, the Committee recommends that, quite apart from other considerations, the tenders received by the Ministry of Transport and Civil Aviation from contractors for work to be done to new specifications should be shown to the Laboratory as a matter of routine, and that steps should be taken to inform the Laboratory of the performance in practice of construction in accordance with new specifications.

Nevertheless, however perfect the liaison between two departments, the Select Committee believes that, where practicable, amalgamation of two related departments is preferable. On the evidence it received, the Committee leans strongly to the view that the Road Research Laboratory would better be placed under the Ministry of Transport and Civil Aviation. This would ensure that the Ministry was aware in advance of what staff and facilities are available and reduce the risk of drawing up research schemes which cannot be undertaken. It should also facilitate the dissemination of the results of the research where they are most likely to be used to advantage. The Ministry, it believes, is in a better position to do this than the Department of Scientific and Industrial Research, just as it could better judge priorities in work affecting its own department; fundamental research at present carried out by the Laboratory could equally well be carried out by the Building Research Station. The Committee quite rightly notes that such fundamental work is likely to apply to a wider field than that of road construction, but it seems to have overlooked the value of fundamental and applied research proceeding side by side in the one laboratory, from the point of view of attracting and retaining staff and of stimulating new ideas. In regard to the former, it was stated in the evidence that the scientific and experimental staff is at present some 7·5 per cent below strength, and that younger men are attracted to places where the research programmes are most interesting.

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* Fifth Report from the Select Committee on Estimates together with part of the Minutes of the Evidence taken before Sub-Committee B and Appendices, Session 1957–58—The Department of Scientific and Industrial Research. Pp. xvi+165. (London: H.M. Stationery Office, 1958.) 9s. net.

The Select Committee, however, is content here with the general recommendation that the Government should specifically consider the question which Department should control the Pest Infestation Laboratory, the Radio Research Station, the Road Research Laboratory and the Water Pollution Research Laboratory. The recommendation is clearly in line with the trend of policy which the new Council has already indicated in its first annual report; but it also suggests that the whole question of the organization of the national research effort is being re-opened and requires consideration from very much wider angles than those of a department. That is also implied in the recommendations relating to co-operation between the Admiralty and the Department of Scientific and Industrial Research; though here, as in its fifth report for the session 1956–57, the Committee is critical of the Admiralty rather than the Department.

The Select Committee accepts the Admiralty's view that problems of ship design and propeller design (see also *Nature*, October 11, p. 988) may differ considerably for warships and merchant ships; but it believes that much greater efforts are required to promote consultation and liaison between the scientists concerned, in order to avoid unnecessary duplication of effort and uneconomic use of facilities, quite apart from the question of availability of knowledge. While the Committee is satisfied that Admiralty knowledge and opinion are fully available to the Department at the most important stage for avoiding overlapping—when the Department's research programme is drafted—the complementary process does not occur, nor are the provisions for making available to the Department the knowledge in the Admiralty's possession satisfactory. The Department of Scientific and Industrial Research has no *ex officio* members of any committee in the Admiralty which plans research, and no opportunity of commenting on the programme which the Admiralty proposes to carry out in their tank at Haslar. Further, no real attempt is made to co-ordinate the use of available facilities for research on ship and propeller design.

Accordingly, the Estimates Committee refuses to accept the view that considerations of secrecy should preclude senior officers of the Department of Scientific and Industrial Research from knowledge of the Admiralty's research plans and makes the following recommendations. First, that the Admiralty should in future afford some officers of the Department an opportunity of commenting on the Admiralty's programme of ship and propeller research at the earliest possible stage, and certainly before the programme is finally settled. Secondly, the Admiralty and the Department should work out a scheme for the regular use of all the available facilities for research in this field by both departments. Thirdly, selected officers of the Department of Scientific and Industrial Research should be given free access to all the scientific information relating to ship and propeller design at present in possession of the Admiralty which the Admiralty would be prepared to disclose if it were specifically requested.

These are sensible recommendations, which, quite apart from their value in checking undesirable secrecy, are in harmony with those which the Select Committee made in the previous session. They point, moreover, to the importance of much closer co-operation between the Defence Research Policy Committee and the Advisory Council for Scientific Policy. If that liaison were in fact satisfactory, it is difficult to see how such recommendations as these could have been left to the Select Committee on Estimates.

BOOKS ON EVOLUTION

Evolution by Natural Selection

By Charles Darwin and Alfred Russel Wallace. Pp. viii+288. (London: Cambridge University Press, 1958. Published for the XV International Congress of Zoology and the Linnean Society of London.) 25*s*. net.

Darwin's Century

Evolution and the Men Who Discovered It. By Prof. Loren Eiseley. Pp. xvii+378. (New York: Doubleday and Company, Inc., 1958.) 5 dollars.

A Century of Darwin

Edited by S. A. Barnett. Pp. xvi+376+5 plates. (London: William Heinemann, Ltd., 1958.) 30*s*. net.

Embryos and Ancestors

By Sir Gavin de Beer. Third edition. Pp. xii+197. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 25*s*. net.

THESE books are some of the many published during the past year in response to the renewed interest in Darwin and his work stirred up by the centenary of the meeting of the Linnean Society in 1858 at which he and Wallace first published the theory of natural selection.

The first book contains reprints of Darwin's essays of 1842 and 1844, which he did not publish, and of the papers given to the Linnean Society. It is prefaced by a short discussion of the present position by Sir Gavin de Beer and by an introduction written by Sir Francis Darwin for the essays when they were published in 1909.

It is useful to have these classical writings in an easily accessible form. They are important for the history of Darwin's thought and especially in showing how clearly he was able to outline his theory in 1842 after no more than five years work. The main part of his paper of 1858 was indeed an almost entirely unchanged extract from the essay of 1844. His views had been scarcely at all altered in the interval. This also appears from the many notes that are given correlating what is said in the essay with parallel passages in "The Origin".

The second book is a history of the development of belief in the fact of evolution and its theory in the nineteenth century. When he comes to write of early genetics, the author extends his account to the first few years of the present century, but he does not go further ; we are told to expect a second volume carrying the story to the present day. The book is a scholarly and well-documented account of the subjects it deals with, but there are some omissions that seem surprising. The reactions in the world outside science are scarcely at all discussed. Perhaps, the author felt that his subject lay in the history of biology and that he should not concern himself with what happened elsewhere. But the interactions were undoubtedly mutual, and a full discussion of the course of events in biology requires some consideration of the development of thought in general.

Less easily understood are two other omissions. The author says very little of the transcendental theories of the early part of the nineteenth century. Darwin may not have been greatly influenced by the work of this type, for it was not his kind of zoology, but it was dominant in the years before he wrote "The Origin" and its theories certainly influenced the reactions of many zoologists to the new theory, especially in Germany (von Baer, Kölliker). Again, anyone reading the book without some previous knowledge would get the impression that the opposition of the early geneticists at the beginning of this century to the theory of evolution by natural selection was shared universally by the biologists of the time. The views of the many who denied the force of the Mendelian evidence against the theory—on the basis of their experience of animals and plants in Nature, of the nature of evolutionary change as seen in palæontological series of strata, and of results such as those of Galton on heredity in man—are not discussed.

All the same, the chapters of the book regarded as accounts of some aspects of the history are valuable, especially, perhaps, those on Darwin's reactions to the claims of the physicists to deny a longer history of the world than a few million years, and on his disagreement with Wallace over the evolution of man. The book should be read, and the appearance of a second volume will be awaited with interest.

The third book contains fifteen short articles by various authors, many of them eminent, on the present position in fields of the study of evolution with which they have been particularly concerned. Most of the contributions are valuable as being clear and concise summaries, but none of the authors has space to do more than this. In fact, the book as a whole suffers from the usual limitations of composite books of this kind. The articles will be useful to anyone who has a sound background of modern views of evolutionary theory, but it is less likely to be useful to those who lack this background of knowledge ; no general view of the present position will be gained. It is not possible to discuss the separate articles in a short review such as this. One contribution, that of D. Michie, on "The Third Stage of Genetics" seems scarcely in place in a volume intended to review "the present status of Darwinian ideas in biology". In it views are expressed which would be unlikely to be endorsed by the majority of geneticists, at least in Britain and America.

The last of these books is less closely concerned with the centenary of the theory of natural selection. It is a revision of Sir Gavin de Beer's well-known book, first published in 1930. The argument is unaltered from earlier editions, but it is expanded with further examples in many places and with three additional chapters on embryology and taxonomy, embryology and homology, and the germ layers. The book is, throughout, concerned with re-interpretation of classical phylogenetic concepts in the light of modern knowledge and in particular with disproof of Haeckel's theory of recapitulation—more a flogging of a dead horse now than it was in 1930, largely owing to the earlier editions of this book—and of the cruder forms of the germ-layer theory. de Beer attributes much importance in evolution to the various types of neoteny, perhaps more than some zoologists would allow. It is good to have this restatement of his views. G. S. Carter

MODERN MICROSCOPY

X-ray Microscopy and Microradiography

Proceedings of a Symposium held at the Cavendish Laboratory, Cambridge, 1956. Pp. xviii+645. (New York: Academic Press, Inc. ; London: Academic Books, Ltd., 1957.) 16.50 dollars.

During the post-war years, one of the major developments in the technique of scientific inquiry has been the spectacular development of microscopy. While electron microscopy undoubtedly scores on the grounds of the high resolution already achieved, the great penetration of X-rays in matter offers great promise in the extension of microscopy to X-ray wave-lengths. The present volume presents the full text of the papers delivered at the first symposium on X-ray microscopy and X-ray micrography together with short extracts of the discussions. All the current techniques of X-ray microscopy – contact X-ray microradiography, reflexion X-ray microscopy and point projection X-ray microscopy – are fully dealt with each by a number of authors distinguished in this field.

The first section deals with the basic principles of these three methods and points out the conditions under which each method finds its greatest application. The following three and several later chapters, referring as they do to the construction of the necessary apparatus including X-ray tubes, will be of greater interest to the experimental physicist than to the prospective user, but nevertheless form a coherent and instructive series. In other chapters methods and techniques are dealt with fully and some applications in biological, medical and metallurgical fields are described.

The total effect left on reading this book is that here is a technique which has not yet reached full bloom but is advancing rapidly. Both contact X-ray microradiography and point projection X-ray microscopy already yield images with resolution at least as good as that in light microscopy, and indications are given that the resolution in the former (also the easier) method is even now so high that attempts are being made to enable the magnification of the original contact image to be achieved in an electron microscope in place of a light microscope. The discussion of reflexion X-ray microscopy is, however, on the whole discouraging.

The papers are somewhat uneven in quality, as might be expected in the unabridged presentation of articles by a large number of authors but, on the whole, the book reads remarkably smoothly and the editors are to be complimented on a compilation which welds the diverse contributions into a coherent whole. The book well repays close study by all workers, particularly biologists, interested in future developments in microscopy.

R. D. Preston

MODERN CYTOLOGY

International Review of Cytology, Vol. 6

Edited by G. H. Bourne and Prof. J. F. Danielli. Pp. x+566. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 12 dollars.

THIS volume contains twelve essays in various fields of cytology, the whole forming a very valuable contribution to knowledge. In some cases the subjects dealt with have advanced so rapidly since the manuscripts were received that their authors could have wished to have been able to add to their conclusions. The antigens of *Paramecia* were first studied so far back as 1905 by Rössle, who showed that rabbits immunized against these Protozoa developed antibodies capable of paralysing them. Sonneborn's discovery of the mating type system of *Paramecium aurelia* made possible further work on cellular processes in general. G. H. Beale of the Department of Animal Genetics, Edinburgh, now discusses the antigen system of *Paramecium.* Beale believes that the hypothesis of autonomous cytoplasmic states, and the hypothesis of variable gene activity, contain possible explanations of most, but not of all, of the known facts.

Sajiro Makino of Hokkaido University, Japan, writes about those remarkable ascites tumours of rats, which can be transferred from animal to animal by injecting a small amount of tumour ascites into the peritoneal cavity with a sharp pipette. Makino's work shows that the most frequently occurring tumour cells possess characteristic chromosome number modes, along with particular patterns, and form a stem-cell lineage, the members of which serve as the primary progenitors. Makino mentions tumours with distinct chromosome numbers—39, 66, 84, 91, etc.—which is a remarkable contribution to the study of cancer.

Arthur W. Pollister and Priscilla F. Pollister write on the structure of the Golgi apparatus. They state that Jan Hirschler originated the idea that the parts of the Golgi apparatus are formed of a thin lamella, or membrane. While we are all for bringing the work of Hirschler before the eyes of the impatient young men who have an electron microscope, we certainly do not consider that Hirschler knew that what he believed to be the lamelliform Golgi membrane was made up of a pile of separate lamellae or saccules usually of fairly definite number. That the blackened "nebenkern batonette" of molluscs is some kind of a multiple structure was first pointed out by Beams *et al.* What also seems important is that Hirschler in 1932, in the *Comptes rendus de la Société de biologie* (109, 1157), first described the *granulated* ergastoplasm in the spermatid of *Macrothylacia rubi.* Hirschler used material fixed in modified Hermann's fluid, then post-osmicated.

From Palermo comes an interesting article by A. Monroy on the fertilization and activation of the egg, and from Berkeley, California, by Robley Williams, a very full review in the role of the electron microscope in virus research. He writes, "We may hope for techniques that will allow us to put our finger on an image of a tiny particle, and say with some confidence that—this is a *virus* particle".

Arthur J. Hale of the University of Glasgow has sixty pages in the histochemistry of polysaccharides. Those who wish to read an authoritative discussion, for example, on the relationship between metachromasia, periodic acid–Schiff staining and polymerization, will find it here. J. Gross of the State University of New York has attempted to relate follicular structure of the thyroid gland to colloid turnover and iodine metabolism. He correlates our knowledge of the nature and function of the parafollicular cells.

Elio Borghese of the University of Cagliari, Italy, has provided a most useful article on the application of histochemical methods to embryonic tissues. One of the most remarkable contributions in this field was the discovery by Chiguoine in 1953 that the primordial genital cells could be recognized in the mouse embryo on the eighth day of gestation by their high alkaline phosphatase rate. This article is recommended for senior students of the comparative physiology of reproduction. R. J. O'Connor of the Westminster Medical School, London, has a speculative review of the information available about the metabolism of the early embryos of the amphibians, the chick, and the sea-urchin. His contribution can be read in conjunction with that of Borghese.

G. Siebert and R. M. S. Smellie of Johannes Gutenberg University, Mainz, and the University of Glasgow, respectively, have contributed an account of the biochemistry of isolated cell nuclei. Conveniently, the next essay by George H. Hogeboom, Edward L. Kuff and Walter C. Schneider is on the cytochemistry of tissue homogenates. These articles are on subjects which are advancing swiftly. George H. Hogeboom died on July 6, 1956, a great loss to his colleagues at Bethesda, and to this difficult and promising field of modern cytology.

The final article by Freda Bowyer of King's College, London, on the kinetics of the penetration of non-electrolytes into the mammalian erythrocyte, is an abstruse and masterly treatment of the problem of red cell transfer. At present no one has devised a decisive experiment which would eliminate any of the three postulated mechanisms—carrier, enzyme, or pore.

J. Brontë Gatenby

AN APPROACH TO ORGANIC CHEMISTRY

A Modern Approach to Organic Chemistry

By Prof. J. Packer and J. Vaughan. Pp. x+973. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 84*s.* net.

THE teaching of a progressive science has been likened to "The Hunting of the Snark" in that the objective is indefinite, changing with time as major research achievements have to be incorporated within limited curricula, and dependent more on the enthusiasm than on the erudition of the teacher. However, a comprehensive text-book should provide a balanced guide to both teachers and students, approaching the advancing front of the subject by the clearest possible route, avoiding laborious minutae of the past and showing circumspection in treatment of theories. In producing a new major text-book of organic chemistry the joint authors, from the University of Canterbury, New Zealand, deserve commendation both for the extent of their labours and for their general plan in attempting to teach essential facts through the clear presentation of electronic theories of molecular structure and reaction mechanisms.

The book is decidedly British in its educational outlook, rather than American or Swiss. The modern approach avoids the usual alternatives either of detailing nineteenth-century structural theories or of crowding an indigestible mass of facts into the opening chapters, and clearly presents in its first 150 pages most essential features of modern structural theories together with the homolytic and heterolytic mechanisms of reaction processes. It achieves this in chapters dealing, by title, with hydrocarbons, their halogen derivatives, and amines. Thereafter the volume deals with other functional groups in the conventional order, placing aromatic chemistry after 500 pages of aliphatic chemistry and ending with but 45 pages of heterocyclic chemistry. Proteins, terpenes, steroids, purines, alkaloids and natural colouring matters do not receive treatment, so that the lengthy volume is suited only to a limited curriculum.

The worst failing of old-fashioned text-books is repeated in that optical isomerization is not introduced until hydroxy-acids are dealt with among bifunctional molecules (p. 371). Walden inversion then gets brief mention (p. 390), though the S_N2 mechanism is described much earlier (p. 114). Consequently, one cannot find in the whole volume the important modern concept of the stereospecificity of bimolecular reaction processes, or even mention of *trans* addition and elimination reactions. Modern ideas of steric hindrance and molecular conformation are clearly beyond the scope of the book: structures for *cyclo*-hexane are correctly given on p. 41, though the interconversion of 'boat' and 'chair' forms is said to be tautomeric. Even later, in connexion with acetoacetic ester, no clear evidence is cited as to why tautomerism is believed to be an acid-base catalysed process, though the diagrams representing reaction mechanisms are correct.

The readable form and the typography of the volume have the invariable high standard of publications of the Clarendon Press, but the chapters on aromatic chemistry contain even more plain hexagons for benzene than Kekulé structures. The two symbolisms are found together even on the same page. It is fortunate, therefore, that the book does not include modern work on alicyclic compounds, since it is now conventional to restrict the use of the plain hexagon to denote the *cyclo*-hexane ring.

Yet, though the omissions from this book of several salient topics of importance cannot be overlooked, the volume does present in a clear, interesting fashion a very large bulk of important factual matter with which chemistry undergraduates need to become conversant. The authors have, in fact, taken a conventional text-book and have added to it, *seriatim*, electronic formulæ for the mechanism of each reaction described. They do this by following meticulously the authoritative guides provided by the monographs of Sidgwick and Ingold. By retaining tables of physical properties they endeavour to maintain comprehensive coverage for a degree course and hence bulk the pagination.

Thus in this essay at a modern text-book of organic chemistry the Bellmen have started on a true course, but their leadership has failed in mid-ocean. Firm handling, with judicious pruning and a wider objective, is needed to make this a text that will command wide respect. W. A. Waters

MICROSAUR RELATIONSHIPS

Revision of the Gymnarthridæ American Permian Microsaurs

By Joseph T. Gregory, Frank E. Peabody, and Llewellyn I. Price. (Peabody Museum of Natural History, Yale University, Bulletin 10.) Pp. x+77. (New Haven: Peabody Museum of Natural History, Yale University, 1956.) n.p.

The Microsaurs are not 'little reptiles' as their name implies but are a group of ancient amphibians that must have arisen in Devonian times, that was certainly abundant in the Carboniferous, and had a few Permian survivors, of which the Gymnarthridae are especially interesting. In general, Microsaurs are not nearly related to the Labyrinthodonts and differ from them in the absence of an otic notch in the skull and in the resulting simplicity of the supratemporal region. They are Lepospondyls and have the notochord invested by bony cylinders.

The Gymnarthridae themselves are an aberrant group that has long been ill defined. Cope described *Pariotichus brachyops* in 1878 from an imperfect skull from the Lower Permian of Texas. E. C. Case described *Gymnarthrus* in 1910 and there has been continued confusion in the identity of this genus itself and in its relationships. *Gymnarthrus* was first thought to be a reptile, then a Stegocephalian, and much of the additional materials collected and studied have contained elements of Captorhinid Cotylosaurs.

Although Case himself did much in later years to help clear up the confusion, the poor state of preservation of much of the material and the small size of the specimens, for Microsaurs are usually but a few inches long, have made elucidation of their relationships difficult.

Within recent years much better material has been obtained from the Permian fissure deposits in quarries near Fort Sill in Oklahoma, and several workers had independently begun revision based on their respective collections. In this volume much of this research has been co-ordinated. The original type specimen of *Pariotichus brachyops* Cope is redescribed and refigured and recognized as a Microsaur, but most of the species referred to this or to supposedly related genera can now be identified as Captorhinomorph reptiles.

The type-specimen of *Gymnarthrus willoughbyi* Case is here regarded as a synonym of *Cardiocephalus sternbergi* Broili, and *Euryodus*, *Goniocara*, *Pantylus* and *Ostodolepis* prove to be related genera, although it is not quite clear at this stage that *Pantylus* and *Ostodolepis* really belong to the family for which the name Gymnarthridae is retained.

These Microsaurs are all small-skulled with short pre-orbital, and long post-orbital, regions. Only *Cardiocephalus* has a parietal foramen. All the above genera, except *Pantylus*, come from the Arroyo formation of the Clear Fork group of the Lower Permian. *Pantylus* has been found in the Clyde and the Putnam formations of the slightly older Wichita group.

Separate sections of the book deal with the auditory region of the Microsaurs and its phylogenetic significance; with Gymnarthrid tooth implantation and succession; and with the postcranial elements.

The authors' conclusions are that the Microsaurs are probably ancestral to the Gymnophionans and are much less closely related to the Nectridia and the Urodela derived from them. The Aistopoda are still more remotely connected. W. E. SWINTON

THE IONOSPHERE

The Ionosphere

Its Significance for Geophysics and Radio Communications. By Dr. Karl Rawer. Translated from the German by Ludwig Katz. Pp. 202+10 plates. (London: Crosby Lockwood and Son, Ltd., 1958.) 42*s*. net.

QUITE apart from its vital role as a propagating medium for the radio waves used in long-distance communication, the ionosphere forms an extremely important and fruitful field for geophysical investigation, and, moreover, one in which there is pressing need for further work to be done—work which embraces several branches of physical science. It is surprising, therefore, considering that the world's communication services are largely established by its means, how little attention is yet given to the ionosphere by the average radio engineer.

To the geophysicist as well as to the radio engineer, therefore, the publication of an English translation of Dr. Rawer's original German book on the ionosphere should be welcome, for though there is a vast scientific literature on the subject, there are very few textbooks upon it.

The author first deals with methods by which the ionosphere is 'sounded', including those of radio reflexion, spectroscopic and geomagnetic observation and with a brief mention of the possibilities of rocket flights. The results obtained by these operations are then dealt with in considerable detail, after which the theory of layer formation is discussed, including that of atmospheric ionization by various solar radiations and that of de-ionization by different processes. Chapter 4 discusses the regular changes to which each layer is subject and also describes the different kinds of ionospheric disturbances and other irregular phenomena. An interesting explanation of the special conditions which prevail within the polar circles is given. The final chapter is devoted to the influence of the ionosphere on radio-wave propagation and to methods for predicting the radio conditions in terms of the usable frequency bands. British, Australian and American methods for doing this are described, but the author devotes most space to the method developed by his colleagues and himself, and which is considerably more complicated than the others. Little information is, however, given as to the accuracy of prediction achieved by any of the methods, and one judges, from the final section, that there is room for improvement in this direction.

The book is of a suitable length for a comprehensive introduction to the subject, though much of the material is very condensed. The translated English is not always good, and this, together with the condensed style, tends to render the reasoning, in parts, a little obscure, which may make the book hard going for the student. Against this, however, is the fact that it is profusely illustrated by line drawings and plates, and frequent samples of data in tabular form are presented. An extensive bibliography is given at the end. Undoubtedly, therefore, the book will serve, for many, as a useful introduction to the ionosphere.

T. W. BENNINGTON

BREWING

A Textbook of Brewing

Vol. 2. By Prof. Jean De Clerck. Translated by Kathleen Barton-Wright. Pp. xx+650. (London: Chapman and Hall, Ltd., 1958.) 105*s*. net.

WHEREAS Vol. 1 was predominantly descriptive in the sense of being concerned with various processes as actually managed in maltings and breweries, the present volume is largely complementary in consisting of an account of corresponding laboratory analytical procedures.

This account of practice in a brewing laboratory covers an extraordinarily wide range and there will be few to whom all the numerous estimations are familiar. For example, in addition to dealing exhaustively with the raw materials of brewing and with worts and beers as commonly understood in Britain, the book includes methods relating to vitamin assays, several antiseptics, synthetic sweetening agents and artificial colouring matters which would not normally come into question in Britain. A further valuable feature is a substantial section dealing with the specification of diverse accessory materials such as filtering agents, pitch, detergents, finings, plastics, varnishes, and various fuels and lubricants. Not least important is the concluding part amounting to about 70 pages, which describes the application of such methods to scientific, including microbiological, control in breweries and maltings. The descriptions of the methods themselves are, of course, factually based on published data as indicated by adequate references, while the applications are more in the nature of informal recommendations, subject to modification according to the circumstances prevailing in individual establishments.

This book is clearly not intended primarily to establish any scientific principles. For example, to take a single example at random, various empirical estimations of the tannins in hops are adequately described, but the reader must seek elsewhere for evidence that the different results can be interrelated or that they refer to recognizable chemical entities. Other topics, such as the determination of the resistance of beers towards the development of haze, are almost matters of controversy. On the other hand, much of the detail, for example, the colours of light of various wave-lengths (p. 25), and many of the illustrations might seem somewhat tedious or even unnecessary to those whose knowledge is such that they might be turning to this encyclopædic volume. Despite these reflexions, however, this book is the most up-to-date and possibly the most comprehensive handbook and reference work of its kind in existence. Its great virtue lies in describing diverse methods in such detail that, thanks in large measure to the excellence of the translation and general presentation, non-specialists can hope to achieve useful results. Within these limitations it is likely to prove invaluable to those engaged in laboratory work in connexion with brewing. A. H. COOK

Tables of Light-Scattering Functions

Relative Indices of Less than Unity, and Infinity. By R. H. Boll, J. A. Leacock, G. C. Clark and S. W. Churchill. Pp. viii + 360. (Ann Arbor, Michigan: University of Michigan Press, 1958. Published for the Engineering Research Institute.) 9·50 dollars; 71*s.* 6*d.*

Tables of Angular Distribution Coefficients for Light-Scattering by Spheres

By Chiao-Min Chu, George C. Clark, and Stuart W. Churchill. Pp. xv + 58. (Ann Arbor, Michigan: University of Michigan Press, 1957.) 3 dollars.

THE scattering of light by small particles is of interest in several fields, for example, aerosol physics, atmospheric physics, astronomy, and colloidal chemistry. The fundamental theory rests on Mie's solution of the Maxwell equations for the interaction of a linearly polarized wave and a single spherical particle of diameter D comparable with or larger than the wave-length λ. The solutions are in the form of infinite series of complex mathematical functions, tabulated values of which are still not available for many important conditions.

In the first of these two volumes, values of the scattering coefficient K and the amplitude functions are tabulated for values of the particle refractive index in the range 0·6–0·93, and also infinity, and for 39 values of $\alpha = \pi D/\lambda$ in the range 1–200. These functions are particularly applicable to bubbles of a gas in a liquid or a solid and to the dispersion of a liquid in another of higher refractive index.

In the second publication are tabulated the scattering coefficients and the coefficients of angular distribution of randomly polarized radiation scattered by a sphere for 9 values of refractive index m ranging from 0·9 to 2·0, and also for $m = \infty$, and for values of $\alpha = \pi D/\lambda$ ranging from 1 to 30.

These sets of tables, which are surprisingly expensive, are to be borrowed rather than bought.

B. J. Mason

Vector Spaces and Matrices

By Prof. Robert M. Thrall and Leonard Tornheim. Pp. xii – 318. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 54*s.* net.

WITH the exception of the final chapter, the book covers well-worn ground, but does so in an interesting and instructive manner, valuable from the teaching aspect. It builds up the instruction through levels of abstraction, from the concrete to the highly abstract. The reviewer has always held the view that an 'abstract' work on mathematics is unsuitable for the elementary student, especially if, as is so often the case, the work is totally, or almost, lacking in examples. Such students often imagine they understand such a work, but later find out that they did not understand in the least. They should be started on a concrete level, with plenty of examples, but not for too long, and then work up gradually to the heights of abstraction. This procedure the book under review carries out, and it is ably written; most of it is suitable for an honours degree course on the subject-matter.

The chapters, in order, are on: vector spaces, linear transformations and matrices, systems of linear equations, determinants, equivalence relations and canonical forms, functions of vectors, orthogonal and unitary equivalence, structure of polynomial rings, equivalence of matrices over a ring, similarity of matrices, linear inequalities.

The final chapter, containing sections on linear programming, the minimax theorem, and matrix games, is interesting in itself.

R. G. Cooke

An Atlas of Airborne Pollen Grains

By H. A. Hyde and K. F. Adams. Pp. xvi + 112. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 36*s.* net.

THIS book is the result of collaboration between a botanist and a medical man engaged in the study of pollen allergy. Its most striking feature is an excellent series of photomicrographs of pollen grains in their natural condition. These have been carefully selected to show the critical features of the grains in both optical section and surface view on a scale of about a thousand diameters. Although many technical terms are necessarily introduced, they are fully explained in the glossary. A well-arranged dichotomous key should make the book a valuable introduction to the study of palynology. Most of the grains illustrated and described are from wind-pollinated flowers, but a number of entomophilous forms are also included.

The book should be a valuable work of reference for the medical palynologist, who will find examples in it representative of all the indigenous pollen types of importance as well as a few exotics, such as *Ambrosia artemisiifolia*, the noxious American ragweed, occasionally found as an adventive in Britain. Apiculturists will also find the book interesting, as many of the anemophilous pollens are utilized by bees as well as the entomophilous forms. The book is admirably produced on glazed paper.

J. Hutchinson

Classics of Librarianship

Further Selected Readings in the History of Librarianship. By John L. Thornton. Pp. x + 203 + 8 plates. (London: Library Association 1957.) 24*s.*

THESE further selected readings in the history of librarianship include little of specific interest to the scientist or even to the technical librarian, save that each selection is accompanied by a biographical note on the author. Among the selections of general interest may be mentioned Sir Edward Bond's remarks on public libraries (from his address to the Library Association), H. Bradshaw's presidential address to the Library Association (1882); W. E. A. Axon's "Professorships of Bibliography"; H. R. Tedder on "Librarianship as a Profession"; T. Greenwood on "The Place of Public Libraries in our National Life"; J. C. Dana's presidential address to the American Library Association (1896); T. Mason's paper on Robert Watt, the author of the "Bibliotheca Britannica"; F. Pacy's retrospect of the Library Association at its fiftieth anniversary conference, 1927; W. W. Bishop on the "Backs of Books"; A. Esdaile's "Confessions of a Victorian"; and W. Blade's "The Enemies of Books". As Mr. Thornton admits, the selections are not all major contributions to major literature and are sometimes presented as typical of an author introduced for his contribution to librarianship in ideas or ideals or work. The biographical notes accordingly give the volume an interest and an appeal which may run outside the purely professional field represented by membership of the Library Association.

R. Brightman

BIOLOGICAL EFFECTS OF RADIATION

AT the Second United Nations International Conference on the Peaceful Uses of Atomic Energy only two of the sessions on isotopes and biology were devoted to what might strictly be called radiobiology. Health and safety in the atomic energy industry and advances in the use of isotopes (in biochemistry, physiology, medicine and agriculture) occupied considerably more of the time of the biological sessions. The First International Congress of Radiobiology had been held only one month earlier in Burlington, Vermont, U.S.A., and undoubtedly this Congress, which had been organized long before the Second Geneva Conference was announced, stole much of the radiobiological thunder. Some material was presented in essentially similar form to both meetings and might thus have reached a wider audience: but if the United Nations is to organize a third conference of this sort, a better integration with meetings of international societies is desirable.

It is convenient to think of the biological effects of radiation as falling into two main classes: somatic and genetic. No startlingly new concepts were expounded in the former, but in the relatively small field of genetics one saw the unfolding of a 'new look'. It has long been axiomatic to consider the induction of true point mutations of genes as strictly linearly proportional to the dose of the inducing agent—ionizing radiation—irrespective of the dose-rate of the radiation. W. L. and L. B. Russell (*P*/897) reported results of their many years work on the induction of mutation at seven specific loci in the mouse. The present indications are that the induction of mutations is not linear at all doses and not independent of dose-rate. Further work is necessary to improve the precision of the observations; for if confirmed, the results indicate that new assessments will be needed of the genetic hazards in a nuclear age.

The fundamentally simple but often tedious approach to the investigation of these genetic hazards is through scoring of point mutations of genes responsible for a single characteristic; but most of the qualities which constitute 'fitness' of an individual are determined by a multiplicity of genes. The Russells have made a first approach to investigation of fitness by scoring the size of litters and the longevity of offspring sired by an irradiated parent: both show reduction compared with controls. The 'fitness' of irradiated populations has also been investigated by Bonnier *et al.* (*P*/169) and Buzzati-Traverso and Scossiroli (*P*/1391) in the fruit-fly, *Drosophila*. The former found that, when there was strong selection pressure by reducing available food supplies, the adaptation to the effects of irradiation with each generation was quicker: it appeared that the increasing heterozygosity was balancing the induced deleterious effects. The Italian workers also found this increased adaptability of the irradiated population to unfavourable environments. The irradiation induced a variability which permitted a more rapid attainment of conditions of equilibrium. There is no conflict here with the accepted law that the induced mutations are mainly detrimental in themselves, but evidence continues to accrue that the rate of evolution is enhanced even with low doses of radiation (Burdick and Mukai, *P*/895).

Whereas man is certainly the ultimate object of study and the mouse is at present the nearest but *Drosophila* the usual model, invaluable information can be obtained even from bacteria, especially in the elucidation of chemical processes. Haas and Doudney (*P*/896) noted that mutation requires cellular metabolism and that starving the irradiated cell of nutrients diminishes the probability of mutation. Amino-acids and energy-sources are pre-requisites.

Of general interest to geneticists and cytogeneticists was the review by Dubinin (*P*/2074), presented by Prokofeva-Belgovskaya, indicating rapidly increasing activity by Soviet scientists in the fields which are generally regarded as orthodox.

When one turns to consider the somatic effects on the individual, it is found that interest is again directed to the prediction of hazard. Therefore, the relationship of dose to effect is one of the most important functions to determine. When there is but a single exposure to radiation, the objective is readily attained experimentally. For most effects the plot of effect versus dose is sigmoid; occasionally a linear relationship like the classical response for gene-mutation is obtained. In the latter case there is a tendency to invoke somatic mutation. There has recently, and perhaps especially in the recent report of the United Nations Scientific Committee on the Effects of Atomic Radiation, been a tendency to give more weight to linear relationships than the evidence justifies, for the confirmed examples are very few. Bond *et al.* (*P*/885) now report a further example; mammary tumours (adeno-fibroma and carcinoma, and fibro-adenoma and sarcoma) increased in Sprague–Dawley rats proportionately to the dose they had received. However, this linearity was obtained only by not scoring beyond ten months. There is a suggestion that the radiation was merely accelerating a natural event. Certainly somatic mutation alone could not be invoked to account for the result, since the manifestation of the tumour was shown to be dependent on humoral influences.

A linear relationship precludes a so-called threshold of dose below which no biological effects can be detected. Without attempting strictly to define the effect–dose relationship, Soviet scientists (Lebedinsky *et al.*, *P*/2068) announced the recording of the effects of very small doses of radiation. By electroencephalography, abnormalities in bio-electrical activity of the cerebral cortex have been seen with doses of the order of 1 r. A similarly sensitive system is claimed for the electroretinogram of the isolated frog's eye.

When one comes to the more difficult problems of interpreting the effects of fractionated doses or of continuous irradiation, the effect–dose relationship may be more complex. Leukæmia, a malignant disease much in the public eye at the moment and not infrequently induced by radiation, has been considered as due to somatic mutation. In mice, however, the results obtained by Mole (*P*/96) in two strains of mice are difficult to fit with this hypothesis, certainly in its simplest form. For equal accumulated doses the incidence of leukæmia within ten months was anything between 6 and 30 per cent: dose-rate or radiation-free time certainly was a relevant factor. Ford and Mole (*P*/98) also showed elegant pictures of the chromosomal changes found in these leukæmic cells.

Malignant disease apart, a general non-specific shortening of life-span has been attributed to the effects of radiation. It could be postulated that radiation, either as a large single dose or a multiplicity of smaller doses, could act as a non-specific stress to give this result. Curtis and Gebhard (*P*/912) found differences in the patterns of mortality of irradiated and non-specifically stressed mice: in their hands the latter did not cause shortening of life. Following single large doses of radiation to the whole body, the earlier deaths are considered by Maisin *et al.* (*P*/109) to be the sequelæ of irradiation of the lung, the intermediate deaths to irradiation of the head and the latest to irradiation of the abdomen. Lindop and Rotblat (*P*/292) also reported their preliminary results in a very large experiment designed to elucidate some of the problems of ageing. Some of the observed effects were startling, which suggests that confirmation with standard strains of mice is highly desirable.

Malignant tumours and shortening of life result from the administration of radioactive materials giving substantial radiation-doses, the pathological changes being related to the chemical characteristics of the material given and its sites of concentration. The report of Burykina *et al.* (*P*/2077) presented by Krayevsky gives details of the late effects produced by administration of fission products to experimental animals. The title of their communication suggests that the doses were small, which is true in terms of mass, but the tissue-doses were measured in kilorads. Lamerton (*P*/61) reviewed the problems associated with the setting of permissible doses of radioactive materials. He believes that the estimation of the radiation-dose with all its present shortcomings provides the most satisfactory criterion. He argues that for the induction of osteo-sarcoma there is almost certainly a threshold which must be many hundreds of rads. Much of the argument is based on the one comprehensive experiment so far carried out on the long-term toxicological effects of radioactive materials; some aspects of this work in Chicago relating to strontium-90 were given by Finkel *et al.* (*P*/911).

Whereas radiobiologists are rightly most occupied at the present time with small doses of radiation and delayed effects, there is still considerable interest in the large single dose such as might be received in an accident, or which might have to be incurred by a few to avoid harm to many. Studies have been aimed at conditioning the body to resist radiation-doses normally lethal. This has not led to any practical measure which could safely be applied, but it has led to a better understanding of the effects of radiation on the intact mammal. Hollaender *et al.* (*P*/898) summarized their latest advances in this field of chemical protection. They favour the view that the main function of these agents is neutralization of free radicals formed by ionizing radiation. In the case of other active agents, biological amines, van der Meer *et al.* (*P*/556) argue convincingly in favour of tissue hypoxia. The role of oxygen in affecting the response of cells and tissues to ionizing radiations has been widely studied and Gray *et al.* (*P*/293) reviewed some of their recent work.

In addition to exploring the possibilities of protection against lethal doses, therapy of the animal lethally irradiated has been actively investigated. Hollaender *et al.* (*P*/898) reported their results of administering blood-forming cells which recolonize the marrow spaces of the irradiated animal. This grafting of homologous tissue may lead to undesirable late reactions. Barnes *et al.* (*P*/97), by cytological methods, have noted in some of these homologous chimæras a reversion of the marrow cells back to host type; apparently the cell clones with the greatest physiological competence, be they of normal donor or radiation-damaged host, ultimately predominate. In both laboratories these therapeutic exercises have involved administration of living cells to the irradiated mouse; but cell-free chemical agents are still being tried. Soska *et al.* (*P*/2121) claim reduced mortality from irradiation following administration of deoxynucleotides (but not following deoxynucleosides). Similarly, Panjevac *et al.* (*P*/490) found improved survival from the administration of deoxyribonucleic acid or ribonucleic acid from homologous spleen or liver, but not from testis.

Experimental work on the intact mammal has been chiefly the theme of this review. This does not mean that radiobiologists are now getting away from the simple systems—the root of the broad bean, the yeast cell and the bacterium. Many of the papers presented were concerned with the basic lesion in these test objects. Equally there were a number of papers primarily chemical, particularly on the chemistry of the nucleic acids; and a paper from the U.S.S.R. on effects of radiation on bio-lipids (Tarusov *P*/2248) indicates the continued interest in that country in the effects of radiation in the nervous system.

The collected papers will, of course, be published by the United Nations Organisation as the Proceedings of the Second Conference on the Peaceful Uses of Atomic Energy.

J. F. Loutit

PHYSICS OF QUANTA AND PARITY

The opening session of Section A (Physics) of the British Association meeting in Glasgow on August 28 was devoted to papers presented by members of the Department of Natural Philosophy in the University of Glasgow. The research work of this Department is mainly concerned with studies of photomeson production and photodisintegration, utilizing the high-energy quanta which are provided by the departmental 340-MeV. synchrotron. Three of the papers presented at this session were concerned with experimental investigations of this type; the fourth, by Prof. J. C. Gunn, professor of theoretical physics at Glasgow, discussed the important discovery during the past year of the non-conservation of parity.

In the opening address, Prof. P. I. Dee traced briefly the development of the concept of quanta from the original suggestion made by Planck, in 1901, to explain the conflict between the experimental results relating to the distribution of energy in black-body radiation and the straightforward predictions of classical theory in terms of the principle of equipartition of energy, which had been so fruitful in the development of the kinetic theory of gases. Compton's demonstration in 1923 that the wave-length changes which occur when X-rays are scattered by electrons could be quantitatively explained by treating the problem as a simple collision process, satisfying laws of conservation of energy and momentum, between a quantum of radiation and an electron, showed that the quantum concept applied to much wider fields than those in which absorption or emission of radiation were concerned.

The whole of the physical world, as we know it, may be regarded as comprised of matter and radiation. It is natural, therefore, that the interactions between the elementary quanta of radiation and the basic constituent particles of matter, neutrons and protons, should constitute one of the frontier problems in modern physics. In processes such as these, mesons are created, and in view of the part played by these particles in relation to nuclear forces, experiments of this nature are therefore not only fundamental to the understanding of the basic phenomena of interaction between radiation and matter but also shed light upon the structure of atomic nuclei.

Recent experiments at Glasgow and elsewhere upon the photoproduction of π^+ and π^- mesons in hydrogen and deuterium permit the comparison of the cross-sections for the production of these particles in reactions of quanta with protons and neutrons, respectively. In these experiments the important principle that nuclear forces are independent of charge seems to receive good confirmation. Similar experiments upon the relative production of $\pi+$ mesons in hydrogen and deuterium provide information upon the dependence on spin of the photomeson production interaction. Studies of π^0 production by quanta in helium suggest that in this process the close proximity of other nucleons has little effect upon the primary interactions between the quanta and the elementary nucleons.

The idea of quantization in physics applies, of course, in a much more profound and general manner than merely in relation to the electromagnetic radiation. The concept of structure in the intervening medium was introduced long ago by Faraday to explain the forces between electrical charges. This concept of the 'field' in physics has now assumed a very wide significance. It is even possible that all the elementary particles of matter, the protons, neutrons, mesons, etc., consist essentially of particular quantized states of a general field. Of what this field consists no one at present can say ; indeed, it may not yet even be sensible to inquire.

In the following paper, Mr. J. M. Reid (Glasgow) gave an account of recent work upon the disintegration of nuclei under irradiation by high-energy quanta. Experiments of this nature have been made with quanta over a wide range of energies, from a few MeV. up to about 300 MeV. At the lower end of this energy region the main feature in the case of all nuclei is a broad or 'giant' absorption resonance which reaches its maximum at a quantum energy of about 20 MeV. and has a width of about 6 MeV. This resonance has been explained as a collective oscillation in which all the protons in the nucleus move together in one direction while all the neutrons move in the other. Such a picture can only provide a rough indication of nuclear behaviour, since it omits all details of the motion of the proton and neutron 'fluids'. Indications have been found of departures from the bell-shaped resonance curve which such a model predicts. In particular, a cloud-chamber investigation at Glasgow has shown strong absorption of quanta of very sharply defined wave-length at the low-energy end of the 'giant' resonance.

A similar cloud-chamber experiment has confirmed a result obtained in American laboratories by other techniques. This concerns the energy region above the 'giant' resonance where, by virtue of its short wave-length, the quantum energy is so localized that only part of the nucleus is affected. A sub-unit greatly favoured in such interactions has been shown to be a single proton–neutron pair. These two nucleons are, as a result, violently ejected as a free neutron and proton, apparently uninfluenced (at least in a large number of cases) by the presence of the rest of the nucleus. Similarly, when this happens, the rest of the nucleus continues in its state of motion despite the plucking of the pair of particles from within its volume. This seems to open up the possibility of investigating, in a more direct way than hitherto, the nature of the internal motion which is occurring within the atomic nucleus.

Dr. J. G. Rutherglen (Glasgow) delivered a lecture devoted to the techniques and uses of millimicrosecond measurements, which have now assumed great importance in atomic and nuclear investigations. For example, the new fundamental particles which have been discovered in the past ten years are all unstable and only live for times between a microsecond and a ten-thousandth of a microsecond. There are many important processes in nuclear physics which take place in comparable, or even shorter, times than this. Measurements of very short time-intervals are therefore necessary to investigate the properties of these particles and processes which are fundamental to our understanding of the basic properties of matter.

The electronic techniques involved in measurements in the region down to a microsecond were developed to a very high degree during the Second World War by the needs of radar and similar applications. At that time the measurements in the field of nuclear physics were limited to about a microsecond by the properties of Geiger counters and similar devices which were then available for the detection of nuclear radiations.

During the past ten years both the detectors and the electronic techniques have been improved in regard to time resolution by a factor of the order of one thousand, so that it is now possible to measure time-intervals as short as one millimicrosecond and to detect even shorter differences in time. The main advance in the detection technique has been the development of the scintillation counter, in which part of the energy of the nuclear radiation is converted into light in a block of transparent material, and the light flash is converted into an electrical pulse by means of a photomultiplier. Techniques of this nature are now commonly employed in many nuclear investigations. For example, $\pi+$ mesons are often identified by measuring the time-interval, of the order of 1/50 microsecond, between the pulse due to the arrival of the $\pi+$ meson and that due to the $\mu+$ meson which results from its decay. Again, the life-times of short-lived nuclear states may in some cases be measured in similar fashion, but the order of time resolution which is so far possible is not yet sufficient for very comprehensive investigations in this particular field.

The second main topic at the opening session was "The Non-Conservation of Parity", which was very clearly presented both in respect of its difficult primary concepts and of its fundamental influence upon basic physical principles by Prof. J. C. Gunn. The recent discovery, following a suggestion of Lee and Yang, that parity is not conserved in certain weak elementary particle interactions, represents a revolution in our ideas of space and time in some ways comparable with the introduction by Einstein of his special theory of relativity in 1906. The essence of Einstein's idea was that the laws of all natural phenomena should be the same for all observers in uniform motion relative to each other. It was automatically assumed that along with this invariance of the equations of physics for transitions to moving reference frames would go invariance to reflexions in space and time. In particular, invariance to reflexions in space is mathematically expressed as the conservation of parity. Put in its simplest form, such invariance simply means that the mirror-image of any physical or chemical system shows a behaviour which could occur in accordance with natural laws in the real world. Effectively, the scientist looking at any experiment cannot say whether what he is seeing is the real thing, or a reflexion in a mirror.

It is indeed true that parity conservation, or invariance to reflexion, is observed for all the more ordinary physical processes—the processes controlled by electrical forces, which account for the physics and chemistry of everyday life, and the processes of more recent interest controlled by nuclear interactions. Of course, local conditions, as, for example, biological systems on Earth, may result in only, say, the right-handed form of some molecule or structure occurring, its left-handed mirror-image being absent. However, this is only a local phenomenon and the left-handed variety is, in principle, quite possible.

This is how things rested when Lee and Yang made their proposal that, though invariance to reflexion holds for the strong electromagnetic and nuclear interactions, it might not hold for weak interactions, such as those responsible for β-decay of nuclei and other decay processes of the unstable particles found in high-energy physics. Their hypothesis has been brilliantly confirmed by experiments, both on β-decay and on the decay of unstable particles, and it is now established that parity conservation is violated over the whole range of weak decays. For example, the neutrino emitted in β-decay always spins like a left-handed screw along its direction of motion. The mirror-image of this would be a right-handed screw neutrino and this is not found to exist.

This left-handedness of the neutrino provides a means by which the physicist can now discriminate between a real and a looking-glass world. An important reservation must, however, be made—the mirrored image of a decay experiment with ordinary matter is impossible as a real process for ordinary matter, but, according to current belief, it represents exactly how anti-matter would behave. Thus, if, possibly in other galaxies, there are worlds of anti-matter their neutrinos are right-handed in our sense. In view of the possible existence of such worlds, no universal significance can be expressed to left-handedness. We might indeed say that, like that of biological systems, the handedness of the neutrino is an environmental character, but the environment is a wide one, consisting of all ordinary matter.

MICROWAVE PHYSICS

THE final session of Section A of the British Association meeting in Glasgow was held on September 3, and was devoted to the subject of microwave physics. It was appropriate that the chair should be taken by Dr. B. J. Mason, for he has acted as recorder of this Section for a number of years and now retires from this onerous and responsible position. The meeting warmly expressed their appreciation of his work.

There were three speakers, and it was soon clear that their papers had been planned to try to give, for the non-expert, some indications of the remarkable developments which have occurred in microwave physics since the War. The first speaker, Prof. K. W. H. Stevens, of the University of Nottingham, began his lecture by giving an elementary account of what is meant by electron spin resonance. The magnetic moment associated with the spin of the electron has two equilibrium positions in a magnetic field, of different energies. The moment can be turned from the lower one to the higher one by supplying a quantum of electromagnetic radiation of the right magnitude. For a free electron the relation between the size of the field and the wave-length of the radiation is $H\lambda = 10 \cdot 70$, where H is measured in kilo-oersteds and λ in cm. For fields of order 3×10^3 oersteds, a convenient laboratory magnitude, λ is approximately 3 cm., which is in the microwave region. Very good oscillators and components are available for these wave-lengths, as a result of war-time radar developments.

Although all substances contain many electrons these are usually paired off, with spins opposed. Such pairs do not show electron spin resonance. Thus to demonstrate the resonance it is essential to work with substances containing unpaired electrons, and it seemed, at one time, that this would provide a serious limitation to the use of the spin resonance technique. This has not in fact proved to be the case, for it is now clear that unpaired electrons occur very widely, and one of the great virtues of the technique is that it can investigate these electrons in detail and thus throw light on problems which are of considerable interest and which are not always easily investigated by other means.

This aspect was particularly emphasized in the second part of Prof. Stevens's talk and by Dr. D. J. E. Ingram, of the University of Southampton, who followed him. The main idea is to use the electron magnetic moment as a probe to find out something about the electron motion. In the course of its motion, the electron may move from one atom to another, in which case there is the possibility that it may interact with the spins of the nuclei around which it moves and thus give rise to resolvable hyperfine structures. Thus, in favourable cases, as the electron explores the various atoms in a molecule or solid, so it gives, by means of the resonance technique, a record of its path. A number of examples were given, and it would seem of value to describe a few of these in some detail. If one takes a mixture of hydrogen peroxide and *iso*propanol and exposes the system to ultra-violet radiation the hydrogen peroxide is broken into two hydroxyl radicals, which are highly reactive and have unpaired spins. They show electron spin resonance. As they now move about in the mixture they attack the *iso*propanol molecules, and transfer their unpaired electrons in exchange for hydrogen atoms, the hydroxyl radical becoming stable water molecules. The free radical formed from the *iso*propanol now shows a resonance which has the typical features expected when an unpaired electron explores six hydrogen atoms. In this way not only is it possible to study how the hydroxyl radicals attack another molecule but it is also possible to learn something about where the transferred electron goes to in the process. Another topical example of a similar nature concerned the existence of free radicals in tobacco smoke. Dr. Ingram reported a preliminary experiment in which he had condensed tobacco smoke at liquid-nitrogen temperatures and had then investigated the condensate. This was found to have a very high concentration of free radicals. The previous example had given an indication of how reactive free radicals are, so it was not surprising to find that he was questioned from the audience about how long such free radicals may exist. This is not known yet, but it could be of the order of seconds. It is thus a sobering thought that every puff of tobacco smoke may transfer to the lungs a large number of very reactive free radicals, and it is clear that this sort of result, though preliminary, may be of considerable importance.

To illustrate the diversity of phenomena which are currently being investigated by this technique, we may mention briefly the following topics which were all described. In semiconductors it is valuable to be able to investigate the properties of minute amounts of impurities, without destroying the samples. These impurities frequently have unpaired electrons associated with them, which can be observed. In coals and oils at about 600° C. it is found that there is a high concentration of unpaired electrons. This may have a bearing on the burning of fuels in internal combustion engines. In polymerization an unpaired electron is found on the end of the polymer and the growth process can be studied. Radiation damage in solids often gives rise to centres which show spin resonance, and the detailed investigation of these, and the comparison with other physical properties, such as colour, are proving of considerable interest.

The third paper was given by Mr. I. M. Ross, of the Services Electronics Research Laboratory at Harlow. His theme was different from that of the previous two speakers, for he chose to discuss the impact which the resonance technique has made on microwaves. A few years ago this could have been a very short paper, for it would be true to say that until very recently the resonance workers have made use of the microwave valves and techniques but have contributed very little in return. However, the recent developments in 'masers', an acronym formed from the initial letters of Microwave Amplification by Stimulated Emission of Radiation, has changed the situation drastically. Two problems which face the microwave engineer are (*a*) how to amplify microwaves and (*b*) how to reduce the noise background in the amplifiers and so increase the sensitivity of the receivers. While masers may not provide the complete answer to his problem they are certainly of considerable promise.

The main idea in a maser is the reverse of that used in a resonance experiment. In resonance use is made of the two spin-levels, and absorption of energy occurs when an electron goes from the lower level to the upper level. If the reverse process occurs, energy is given out. In thermal equilibrium there are always more electrons in the lower state than in the upper state, so that, although radiation may persuade those in the upper states to de-excite, it also persuades those in the lower state to excite, and there is always a net absorption of energy. To get a net emission of energy (for this is what is needed for amplification of microwave signals) it is necessary to have an arrangement whereby one starts with more electrons in the excited state than in the ground state. For continuous amplification this situation must be maintained, but for pulse amplification the emissive state need only be obtained while the pulse is actually being amplified. The problem of getting more electrons (or atoms) into the upper than lower state has caught the imagination of a number of physicists, and a variety of ingenious suggestions have been made and tried.

One of the simplest to understand is that which uses a beam of ammonia molecules, though this does not use the spin energy difference. Ammonia molecules have two closely spaced energy-levels and if one takes a beam of ammonia molecules it is possible to split the beam into two, one containing only molecules in the lower state and the other containing only molecules in the upper state. The molecules in the second beam can then be used to provide energy, by de-exciting them. This system does not lend itself to microwave amplification because of its narrow band-width, but may well provide us with a frequency standard which is more stable than any previously obtained. To increase the band-width and to make amplifiers instead of oscillators it is necessary to go to solids, and then there is no possibility of geometrically separating the excited atoms or molecules, so other methods must be sought. One very ingenious device uses three energy-levels. In this, energy is provided by microwave radiation to promote atoms from the lowest to the uppermost level. Provided that enough power is available it is possible to equalize the populations of these two levels, so that the upper level has gained atoms at the expense of the lowest level. The third, intermediate level, takes no direct part in this, and it is possible to reach a situation in which more atoms are in the uppermost level than are in the intermediate level. A relative population reversal has occurred and emission instead of absorption can be achieved on irradiating the system with microwave radiation corresponding to the energy difference between the middle and upper levels. There are a number of problems involved in actually making a device which works on this principle, as can perhaps be inferred from the fact that one of the most promising maser materials is ruby, which is an impure form of aluminium oxide, containing chromium impurities. The aluminium oxide provides a very good medium in which to have the paramagnetic chromium ions.

A somewhat similar type of amplifier is that which has been known since the days of Lord Rayleigh, and which has recently come into its own in the microwave field. This is the so-called parametric amplifier, and in essence it uses a time-dependent reactance to couple together two resonant systems, in such a way that energy is fed from the reactance variation to the resonant systems. The microwave engineering of this is quite complicated, as was evident from the slide shown, but such devices have been made to operate using either ferrites or garnets as the active material.

In the solids no electron beams are used in obtaining the amplification, and the only sources from which thermal fluctuations can arise are in the devices themselves, in their associated circuitry and from the driving oscillator. The masers have so far only been operated at liquid-helium temperatures (though it is possible that they may be usable at higher temperatures), and have extremely low noise. The parametric amplifiers will work at room temperature, which is a distinct advantage, but they are noisier than the masers, but comparable if not better than any other types of microwave amplifiers.

The immediate applications for which these amplifiers could be very valuable include their use in radio astronomy to detect the microwave radiations from outer space, in communicating with and observing Earth satellites and in increasing the sensitivity of radar systems.

The field of microwave physics which looked a few years ago to be a very specialized and limited one is in fact broadening out in much the same way that nuclear magnetic resonance has developed. Electron spin resonance apparatus is no longer to be found in a few university laboratories, for a number of industries and hospitals have realized its potential value, and there seems every likelihood that its value will be more widely appreciated in the next few years.

In view of this year's theme of the Association, it seemed appropriate to close Section A with an account of the way in which a rather specialized laboratory technique promises to become a powerful tool for industry, and it will be a very good example of the value of pure research to industry if the maser developments have their expected impact on the microwave industry.

K. W. H. STEVENS

TRENDS IN METALLURGY

SIR ANDREW McCANCE in opening, on September 1, the session before Section B (Chemistry) of the British Association meeting in Glasgow, dealing with "Some Recent Trends in Metallurgy", reviewed in broad outline the progress made in the scientific world during the past few years and emphasized the important part that metallurgy had played in making this possible. He said the standard of living of industrial countries was indicated very largely by the steel consumption per head of population. By this standard the United States led the world with Germany and Britain 20 per cent and Japan 85 per cent below the American standard. British production per man employed had increased by 55 per cent since the War. This truly remarkable achievement had been brought about by an increase in the size of the producing unit, by improved equipment and by advances in technical knowledge such as the use of oxygen in steel-making.

The impact on metallurgical practice of the ever-increasing demand for materials to withstand higher temperatures and pressures had been very marked and he felt that the difficulty of finding metals of such strength to withstand working temperatures of 800–900° C. would cause a definite hold-up in progress. Though it was dangerous to argue from analogy, and we had only the most elementary guide to a pathway through the wilderness of ignorance, it was not out of place to point out that the most successful high-temperature alloy to-day was based on nickel with a melting point of 1,450° C. and chromium with a melting point of 1,850° C. The science of metals had lagged behind the technology of their use, and more imaginative work on factors contributing to their strength properties was a field offering great practical possibilities.

Creep and brittle fracture were two interesting problems of a fundamental nature, and though they had given rise to innumerable papers and much discussion yet remained in about the same state of advancement as they were ten years ago. In the case of brittleness it would appear that the results depended just as much on the type of test as on the nature and condition of the material being tested. A completely new approach to this problem would be welcome.

In the science of metals progress had resulted from the work of physicists rather than of metallurgists, and the fascinating developments in the use of semiconductors like germanium and silicon and the immediate applications to which inventions based on these discoveries had been put are outstanding achievements. However, during the past ten years much had been written about dislocations and they had been brought into the explanation of every conceivable property that metals possess. Sir Andrew regretted, however, that in many of these explanations there was more mathematics than physics and thought it doubtful if any real quantitative contribution had been made to our knowledge of the properties of metals by the dislocation theory, although it had contributed to our qualitative understanding of why metals behave as they do.

In a discussion of some recent applications of chemistry to metallurgy, Prof. R. Hay and Dr. P. T. Carter described the development of the modern highly mechanized iron blast furnace. Most of this development had resulted from the efforts of the engineer, but more recently, the metallurgist, using a chemical approach, had made important contributions. Investigations into the rate of reduction of different ores had led to the use of properly sized burdens, and petrological studies of the changes occurring during sintering into lump form of the fines produced during crushing, or blown out of the top of the furnace, had shown that the formation of fayalite (Fe_2SiO_4) caused a serious decrease in reducibility. Later work showed that fayalite formation could be avoided if the iron oxide particles could be bonded together by diffusion in the solid state, without melting occurring.

When melting could not be prevented, fayalite formation could be avoided by adding lime to form calcium silicate. In smelting lean ores, the incorporation of lime in the sinter mix ensured at the same time intimate mixing of the gangue and flux, and easy reducibility of the iron oxide, and now all the ore can be converted into easily reducible sinter, with a reduction of about 30 per cent in coke requirements.

Recent research into the constitution and properties of blast furnace slags was also described. A knowledge of their viscosities and melting points, and of their ability to control impurities in the iron such as sulphur and silicon, had contributed considerably to improved blast furnace practice in recent years.

The important effect of impurities on metal properties was described, and methods for their removal were discussed. Selective oxidation of impurities was well known, and recent compilations of thermodynamic data on metal/oxide systems allowed quantitative assessment of such methods. Selective chlorination could also be used, as in the removal of zinc from lead, and it was suggested that recent improvements in fluorine technology might result in similar applications for fluorine.

These methods introduce elements which may be as harmful as the original impurities. After selective oxidation, suitable deoxidizers—the choice being determined by cost, solubility and the formation of easily removable products—could be used, but the metal still contained small amounts of deoxidizing elements. The nearest approaches to the production of pure metal had been obtained by complicated and protracted chemical methods, or the comparatively simple zone-melting techniques developed by Pfann. Remarkable degrees of purification were possible, and in the case of germanium, impurities which affected its electrical properties could be reduced to less than one atom in 10^{10}. Similar degrees of refining were possible with gallium and antimony, and most of the impurities could not be detected even by spectroscopic methods. Problems of contamination from the container used in the zone refining of reactive high melting point metals such as silicon, iron, germanium, etc., had been overcome by the use of floating zone techniques, in which no container was used, the molten metal being held in place by its own surface tension. Iron prepared thus showed ductility even at temperatures approaching 0° K.

Gaseous impurities were more difficult to remove, but recently, induction vacuum melting and consumable electrode vacuum arc melting had been successfully applied to the production of large ingots. The former had been used particularly for the nimonic type of alloys, since it afforded close control of composition, and for certain special steels, and ingots up to 2,000 lb. had been made by this process. Consumable electrode processes in which air-melted electrodes were consumably remelted in water-cooled copper crucibles were now an integral step in the production of titanium, zirconium, molybdenum and many special alloy steels. They were less costly than vacuum induction melting, and could make ingots up to six tons.

Both processes were costly for the large tonnages usually encountered in steel-making, but vacuum degassing in the mould, which was cheaper and simpler, had resulted in considerable reduction in the hydrogen, nitrogen and oxygen contents of steel.

The newer metals in industry were discussed in a paper presented by Dr. H. M. Finniston and Dr. P. Murray. They pointed out that the newer metals fell into two groups. The first had a specific purpose for which it was difficult to see applications outside the field for which they were originally developed. To this group belonged uranium, thorium and plutonium, with perhaps germanium and silicon. The second group, which included titanium, zirconium, beryllium, niobium and molybdenum, was likely to have a wider field of application. For example, zirconium has very good corrosion resistance and niobium has potentialities as a high-temperature creep-resistant material.

There were, however, several similarities between these metals. The extraction processes, because of the stability of their oxides, were all relatively complicated. All these metals were reactive and in many cases their physical properties, especially ductility, were adversely affected by small concentrations of gaseous impurities such as hydrogen, oxygen and nitrogen. This had led to developments in vacuum melting and casting techniques. In the case of the very high melting point metals thorium and niobium, powder metallurgy techniques had been employed with advancement in the use of high-pressure and high-temperature vacuum-sintering operations. The physical metallurgy of some of these metals was complicated due to the number of phase changes and to their alloying behaviour not conforming to the pattern of the more common metals.

In discussing the first group of metals the authors pointed out that the most interesting and important feature of uranium was its behaviour as a fuel in a reactor when bombarded with neutrons and this had introduced a completely new problem in metallurgical studies. At temperatures up to 350° C., growth occurred due to change in crystal shape, and at temperatures higher than 350° C. swelling of the metal took place. The former—generally referred to as 'wrinkling'—occurred in material with a marked texture and could be overcome by obtaining a randomly oriented fine-grained structure prior to irradiation. The latter effect was due to the nucleation of bubbles of the inert gases, krypton and xenon, produced by fission. This was accompanied by a marked decrease in density of the metal.

Plutonium, the synthetically produced metal from the uranium in the reactor, was metallurgically unique in that it existed in six different phases between room temperature and its melting point (630° C.). Two of these phases exhibited negative coefficients of thermal expansion.

Of the second group of metals titanium was the most extensively used, largely as a structural material in alloy form in the aircraft industry. In the range 200–400° C. titanium alloys possessed a better strength/weight ratio than either of its competitors, aluminium alloys and alloy steels. Above 400° C. alloy steels were superior. Zirconium, although a high melting point metal, was also disappointing in that at medium temperatures its strength, like that of titanium, was not very good. All the early zirconium metal contained small quantities of hafnium, but although this metal is an identical twin of zirconium in chemical behaviour, in the nuclear reactor there is no such similarity. Though zirconium was virtually transparent to neutrons, hafnium absorbed so many that it is considered a most suitable material of construction for reactor control rods. Zirconium is primarily a sheathing material in pressurized water reactors where good corrosion resistance in water at temperatures up to 325° C. is essential. Zirconium alloys have been developed with corrosion-rates as low as 1/5,000 in. per annum.

Knowledge of beryllium and its properties has advanced considerably over the past ten years largely as the result of its potential applications in nuclear reactors. It has been used for many years as an alloying element particularly with copper. The metal is extracted by two methods. The principal method is the thermal reduction process using magnesium reduction of beryllium fluoride at temperatures above the melting point of beryllium. The metal forms as globules which float to the surface of the bath. For removal of magnesium fluoride, melting *in vacuo* or under partial pressure of argon is employed. The other method of production uses the electrolysis of fused salts, mostly the eutectic mixture of sodium and beryllium chlorides, although fused fluorides have been used. Beryllium can be extruded over the temperature-range 400° C.–1,000° C. Sheathing of the metal provides a solution to the health hazard, iron being the usual sheathing metal. A technique using the combined operations of powder metallurgy, consolidation and extrusion has been successfully developed. Beryllium is associated with inherent brittleness due to cleavage occurring along the basal plane. Attempts have been made to produce very pure beryllium. Zone refining has given disappointing results; but evaporation of vacuum-melted high-purity electrolytic flakes has yielded a very pure metal having an oxygen content of 10 parts per 10^6. Such small crystals as were tested fractured in the normal fashion. Above 400° C. the mode of failure changes from transcrystalline to intercrystalline; but the reasons for this change are unknown. In spite of such difficulties the metallurgist has succeeded in developing a wide variety of fabrication techniques and has also succeeded in joining beryllium to other metals and to itself.

Several methods have been proposed for the production of niobium such as electrolysis of fused potassium niobium oxyfluoride, the reduction of the oxide by the carbide and the reduction of potassium niobium fluoride by sodium or magnesium. The main method of consolidation is sintering of cold-pressed compacts. Niobium metal is an excellent 'getter' absorbing both oxygen and nitrogen rapidly on heating. Hydrogen is also absorbed at temperatures up to 500° C. The elimination of non-metallic elements is essential for the production of ductile metal. The three main methods of purification which can be utilized during sintering are: (1) low-temperature eliminations of hydrogen up to 1,100° C.; (2) the formation of carbon monoxide above 1,650° C.; (3) the elimination of oxygen probably by volatilization of an oxide of niobium at temperatures above 1,900° C.

An important factor in attaining sound bars is the correct grading of the powder. Too fine powder sinters too quickly at the surface, resulting in retention of the gases and ultimate formation of gross internal voids. The sintered bar is cold forged and re-sintered at a maximum temperature of 2,300° C. The resulting pure metal is ductile and can be formed cold by most of the usual methods. Hot forming is not possible owing to the pick-up of gases resulting in embrittlement. At present its only industrial use is in nuclear reactors as a canning material. If alloy development succeeds in realizing the potentialities of niobium as a high-temperature creep-resistant material and can overcome its poor oxidation resistance the field of possible application will be widened considerably.

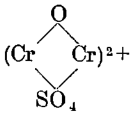
In the final paper Dr. N. P. Inglis and Mr. J. B. Cotton discussed the corrosion behaviour of tantalum, niobium, titanium, zirconium and beryllium. All these elements readily form oxides, and this in part is a factor in their very resistant behaviour under a wide range of conditions. The oxide film can prevent further attack provided this film is very closely bonded to the metal. Investigations of the attack of various solutions ranging from hot fuming sulphuric acid through hot neutral salt solutions to hot strong sodium hydroxide solutions on these metals had shown that tantalum was the most resistant, being closely followed by niobium, while beryllium was attacked by all the corrosive media. Titanium had good resistance to neutral chlorides and it was estimated that titanium sheet of the thickness of a postage stamp would take four thousand years to disappear in sea water. Titanium, though not nearly so resistant to attack as tantalum, was much cheaper and showed fair resistance to non-oxidizing acids. This suggested further examination of the possibility of forming protective films to raise its resistance to that of tantalum, and it was shown that the growth of oxide films could be stimulated by slightly raising the oxide potential of the metal when in contact with the corroding medium. The method of raising the potential was not important, provided its value exceeded a certain critical value. Titanium could be protected by connecting it to a more noble metal such as platinum or carbon. This was shown with the aid of cine-film in which the behaviour of a piece of titanium without protection was compared with that of another piece to which a protective potential was applied. Another example of protection was shown in which titanium with an extremely thin surface-film of platinum and another piece without such protection were immersed in a current of sea water.

R. Hay

A NOVEL TYPE OF METAL-PROTEIN COMPOUNDS

By Prof. K. H. GUSTAVSON

Garverinäringens Forskningsinstitut, Stockholm

All proteins are capable of binding metal ions, but the extent of binding and the stability of the metal-protein compounds vary greatly both with the nature of the metal ion, the nature of the protein and its net charge[1]. The transition group elements possess the greatest affinity for proteins generally and form the most stable compounds[1]. Positively charged polynuclear chromium complexes, such as  $(\mathrm{Cr}\overset{\mathrm{O}}{\underset{\mathrm{SO_4}}{\diamond}}\mathrm{Cr})^{2+}$, are held very firmly, so that no dissociation of the metal-protein complexes is detectable. The co-ordinate bond formed is largely covalent. The chromium complexes are potent cross-linking agents, stabilizing the protein. Thus, collagen binds basic chromium sulphate tenaciously; a reaction utilized in the important process of chrome tanning of leather. The chromed hide resists the action of boiling water and proteolytic enzymes. It is now generally considered[2] that in the initial reaction the cationic chromium complexes discharge the carboxylic ions of the protein. The electro-neutralization of the charges of the components of the system is followed by penetration of the carboxyl groups into the chromium complex, which results in the formation of co-ordinate-covalent bonds of great stability between the carboxyls and the chromium atoms of the complex.

Chromium-collagen compounds. Chromium is an exceedingly versatile metal so far as the formation of complexes goes. In aqueous solution of basic sulphates, polynuclear complexes with positive and negative electric charge as well as uncharged ones may be present simultaneously. The degree of affinity of the ligands for the chromium atom governs the nature of the complexes formed. Apart from the common type of cationic chromium-carboxyl compounds, other combinations are known, such as compounds with anionic chromium complexes attached to the ε-amino groups of the lysine residues and the guanidyl group of the arginine residue. These chromium-collagen complexes do not attain the exceptional stability possessed by the normal carboxylate type. Furthermore, it has been suggested that the hydroxy group of the hydroxyproline residue participates in the binding of non-ionic sulphito-sulphato-chromiates by collagen[2]. The present article outlines the reaction of neutral chromium complexes present in extremely basic chromium perchlorates with collagen. This reaction leads to the formation of an entirely new type of metal-protein complexes in which the uncharged chromium complexes are attached to the protein through its non-ionic keto-imide groups. Judging by the stabilization obtained by the fixation of these chromium perchlorate complexes, they cross-link the protein units. This novel class of metal-protein compounds should appear to be of general chemical interest, particularly from the points of view of the behaviour of proteins and complex chemistry.

The basic chromium perchlorates corresponding to the empirical formula: $Cr_2(OH)_{6-n}(ClO_4)_n$, where $n \geqslant 4$, their composition designated as per cent acidity $\left(\frac{n}{6} \times 100\right)$ in the following, contain in dilute and moderately concentrated solutions only positively charged complexes, free from ClO_4^- groups. By increasing the number of hydroxyl groups, stable aqueous solutions are obtained, containing compounds of the type $Cr_2(OH)_{6-n}(ClO_4)_n$, with $n \leqslant 2$. Most of these complexes do not migrate on free electrophoresis and do not react with ion exchangers. Thus, solutions of the 33 per cent acid perchlorate contained about 65–70 per cent of uncharged complexes and 30–35 per cent of cationic ones. The composition of the complexes first mentioned corresponds to the formula $(Cr_2(OH)_5ClO_4)_m$, and of those last mentioned to $Cr_2(OH)_2(ClO_4)_4$. The average molecular weight of the 33 per cent acid perchlorate, estimated by measurement of diffusion, indicates values of m equal to 2 or 3. The purely cationic complexes of the 67 per cent acid salt contain two chromium atoms on the average[3]. These react with collagen in the usual way, attaching themselves to the charged carboxyl groups of the protein. The neutral chromium complexes of the extremely basic perchlorates show an entirely different type of reaction with collagen. A résumé of some results obtained on investigating the mechanism of their fixation by hide protein follows. Detailed accounts of these researches will be given elsewhere.

Table 1

No.	Substrate	67 per cent acid chromium-perchlorate (m.equiv. chromium fixed by 1 gm. collagen)	33 per cent acid chromium-perchlorate m.equiv. chromium fixed by 1 gm. collagen	(Per cent acidity of chromium-collagen-compound)
1	Hide powder (H.P.)	2·1	4·4	27
2	Heat-denatured H.P.	2·2	7·9	20
3	Esterified H.P.	0·3	2·7	—
4	Deaminated H.P.	1·8	4·9	25
5	N-acetylated H.P.	2·0	4·2	—
6	N- and O-acetylated H.P.	1·9	5·6	—
7	H.P. pretreated in 2 *M* $NaClO_4$ solution for 7 days	2·4	9·1	18
8	H.P. tanned with tannic acid; 92 per cent tannin fixed by collagen	1·5	0·3	—
9	Polyamide	0·1	3·4	17

The solutions of the extremely basic chromium perchlorates, 33 per cent acid or less, were prepared by addition of sodium hydroxide, in 10 per cent solution, to a solution of the 67 per cent acid perchlorate, which in its turn was obtained by boiling freshly precipitated hydrous chromic oxide (from hexaquochromium chloride) with the required amount of perchloric acid. The final solutions, containing 1·00 equiv. chromium per litre, were at least six weeks old when used. The *p*H values were 3·4 and 2·9, respectively.

The complex composition of these solutions of the 33 and 67 per cent acid chromium perchlorates was ascertained by the ion exchange method[2], employing the sodium salt of 'Dowex-50' and the perchloric acid salt of 'Amberlite IRA-400'. The 33 per cent acid compound contained 72 per cent uncharged complexes of 17 per cent acidity, the rest being cationic. The 67 per cent acid chromium perchlorate contained positively charged complexes only.

Reaction with collagen and modified collagens. In Table 1, results on the irreversible fixation of these two chromium perchlorates by specimens of intact collagen and various modified collagens are given. In these experiments, portions of the substrate equal to 1·0 gm. of collagen were made to react with 25·0 ml. of the solutions of the chromium perchlorates for 120 hr. The degree of chromium fixation is stated in m.equiv. chromium bound by 1 gm. of the protein. The preparation and properties of the specimens of modified collagen were described in a recent monograph[4].

The results in Table 1 indicate the following facts. By increasing the number of co-ordination sites on the collagen, that is, uncompensated —CO·NH— links, by heat shrinkage (No. 2) and by pretreatment of the hide powder with concentrated solutions of lyotropic agents (No. 7), the fixation of the chromium complexes in the form of neutral compounds is practically doubled, while the fixation of cationic chromium complexes of the 67 per cent acid chromium perchlorate is only slightly affected. This indicates the dominance of the keto-imide groups of collagen in the fixation of uncharged chromium complexes. By the inactivation of the carboxyl groups by methylation (No. 3), the binding of the cationic chromium complexes is practically eliminated, whereas the uncharged complexes of the extremely basic perchlorate still show marked affinity for the modified collagen, the amount of chromium fixed being about 60 per cent of that of intact collagen. By complete acetylation of the ε-amino groups, or by their diazotization, the reactivity of collagen towards the chromium perchlorates is changed very little. In the case of the exhaustively acetylated specimen, with all the ε-amino groups and the major part of the hydroxy groups affected, the fixation of the extremely basic perchlorate is favoured, while that of the cationic chromium complexes is slightly lowered. The markedly increased reactivity of the completely acetylated collagen with the non-ionic chromium complexes is probably due to the freeing of some of the —CO·NH— links from the hydroxy groups of the hydroxyproline residue, making additional sites available for hydrogen-bonding[5].

In specimen No. 8, with practically complete blocking of the —CO·NH— links and a partial inhibition of the reactivity of the ionic protein groups, the uptake of uncharged chromium complexes is practically prevented, while the cationic chromium complexes still show great affinity for the tanned collagen. The lowered fixation is, in the latter instance, probably to be accounted for by the impaired reactivity of the ionic groups of collagen resulting from its binding of tannic acid[2]. All these findings are in harmony with the supposition that the uncharged (non-ionic) chromium complexes of the 33 per cent acid perchlorate are reacting with and attached to the keto-imide groups of collagen. Final proof is provided by the large fixation of the chromium complexes by the modified polyamide, which fixes about 75 per cent of the amount of chromium bound by intact collagen from the 33 per cent acid chromium perchlorate. The polyamide is inert to cationic chromium complexes which require ionic carboxyl groups for their fixation. Its reactivity is limited to the —CO·NH— link.

Hydrothermal stability. As a measure of the degree of effectiveness of the two types of chromium complexes in stabilizing collagen, the determination of the temperature of shrinkage, T_S, is a simple but very informative indicator. Specimens of isoelectric calf-skin, which had been tanned with the 33 per cent acid chromium perchlorate to contain 3·1 m.equiv. chromium per gm. of collagen, commenced to shrink in water of 84–86° C. Specimens which had been tanned with the 67 per cent acid chromium perchlorate to contain 2·0 m.equiv. chromium per gm. of collagen shrunk at 92–94° C. It should be noted that by the binding of about 2 m.equiv. chromium per gm. of collagen in the form of cationic sulphato-chromium complexes, complete resistance of the chromed collagen to boiling water is obtained ($T_S >$ 100° C.). In this connexion, it is of interest and of some significance to note that by fixation of vegetable tannins, that is, polyphenols which are hydrogen-bonded to the keto-imide groups at several points, the shrinkage temperature of skin collagen is increased to 80–90° C. by the most effective tannins[2]. The degree of stabilization of collagen obtained in the two processes, the vegetable and this non-ionic mineral tannage, involving mainly —CO·NH— links, is evidently of the same order of magnitude.

Reaction with gelatin solution. Gelatin is the classical reagent for vegetable tannins, already studied by Davy[6]. In slightly acid solution (pH 3–4), gelatin forms a copious precipitate with solutions of tannins. Since urea-formaldehyde condensation products, which contain the —CO·NH— link as the chief functional group, are equally effective precipitation agents for vegetable tannins as gelatin[7], the reaction is generally believed to be an attachment at several points of the polyphenol to the —CO·NH— links of adjacent gelatin molecules, resulting in the formation of insoluble aggregates[8]. Cationic chromium complexes do not show this reaction. However, by adding a solution of the 33 per cent acid perchlorate to the gelatin solution, a bulky precipitate was formed. It was filtered off immediately, washed and analysed for chromium, perchlorate and protein (nitrogen × 5·56). The filtrate was also analysed. The results are given in Table 2.

Table 2. PRECIPITATION OF GELATIN SOLUTION BY SOLUTION OF 33 PER CENT ACID CHROMIUM-PERCHLORATE

Reaction balance :	Chromium (m.equiv.)	Perchlorate (m.equiv.)	Per cent acidity
Original solution	10·00	3·30	33
Residual solution	4·10	2·24	55
Fixed by the gelatin	5·90	1·06	18
Fixed by 1 gm. of protein	*14·8*	*2·65*	*18*

The following technique was used. To a portion of 40·0 ml. of 1·0 per cent gelatin solution (400 mgm. of protein), a quantity of 10·0 ml. of the 33 per cent acid chromium perchlorate, 1·00 equiv. chromium per litre, diluted with 30·0 ml. of water, was gradually added with constant shaking. The gelatin used in the series of Table 2 was a normal type of alkali-processed calf-skin gelatin, with its isoelectric point at pH 5·0.

By direct analysis, it was found that the chromed gelatin contained 21·8 per cent chromium sesquioxide, 58·9 per cent protein and 15·0 per cent perchlorate. The per cent acidity of the fixed chromium salt was 17. 14·6 m.equiv. chromium was fixed per gm. of protein.

The keto-imide link as the binding site. The fixation of vegetable tannins by the polyamide proves that the —CO·NH— link is its main reacting centre. Since the hydrogen atom of the phenolic group is the donor in the hydrogen-bond formed with the keto-imide group, its oxygen atom should be the acceptor. That the hydrogen atom of the —CO·NH— link is not necessary for the reaction is proved by the fact that structures containing the —CO·N= group alone, corresponding to the link formed by condensation of the prolines in the collagen chains, possess marked affinity for polyphenols of the vegetable tannin type. Polyvinylpyrrolidone is such a model substance[9]. A precipitate was also formed when a 2 per cent aqueous solution of polyvinylpyrrolidone was gradually added to a solution of chromium perchlorates with per cent acidities less than 33. This test is an additional indication that the complex formation with the non-ionic chromium is localized to the oxygen atom of the keto-imide group. However, gelatin is by far the most efficient precipitating agent for the uncharged chromium complexes, which might be due to the participation of auxiliary groups of the protein, lacking in the polyamide and polyvinylpyrrolidone.

By the fixation of cationic chromium complexes by collagen, its isoelectric point is shifted towards higher pH values, or from $p\mathrm{H_I}$ 5 to $p\mathrm{H_I}$ 7–7·5[2], due to the partial inactivation of carboxyl ions of the zwitterionic protein. Applying the dye-technique, the pH_I was found to be 5·5 for the chrome-collagen compounds obtained by tanning with the extremely basic perchlorates of chromium. Thus, no appreciable displacement of the original isoelectric point of the collagen occurred due to the non-ionic chrome fixation. The binding of chromium by the non-ionic protein groups should not be expected to affect the location of the pH_I.

The results of the present investigations suggest that the keto-imide group of collagen is responsible for the irreversible binding of the nonionic chromium complex of extremely basic perchlorates of chromium. No definite information on the nature of the valency forces involved in the attachment of the chromium complexes to the —CO·NH— link at several points has as yet been obtained, whether the binding takes place by co-ordination of the oxygen atom of the keto-group on the chromium complexes, the formation of some type of hydrogen bond, or by ionization of the —NH— link, or by a combination of such reactions. Rabin[10] and Murphy and Martell[11] have presented evidence that peptide oxygen rather than peptide nitrogen is involved in the reversible interaction of some metal ions with simple peptides. The findings of improved hydrothermal stability and the changed reactivity of the chromed collagen, as well as the ability of the non-ionic chromium complexes to precipitate gelatin are satisfactorily explained by a reaction involving co-ordination of the chromium atoms on the oxygen atom of the keto-group of the keto-imide link. The main feature, which is firmly established, is that the compounds formed represent a novel type of metal-protein compounds which may be of value for the location of uncompensated keto-imide links in proteins, for example, by modern optical methods.

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OBITUARIES

Mr. R. W. Sloley

THE news of the death of Mr. R. W. Sloley, of Amersham, Bucks, on August 19 at the age of seventy-nine, has been received with sorrow by a large circle of friends and scholars. He took his degree at St. John's College, Cambridge, and he never lost contact with his University. After graduating, he joined the staff of Liverpool College, but during the First World War he went to the Department of Instrument Inspection of the Air Ministry, where he remained for the rest of his professional career. He speedily made his mark in this Department, and during the War spent some time stationed in France. When peace came, he continued his work at the Air Ministry depot at Kidbrooke, and during his service there he wrote a book on aircraft instruments which ran into several editions and is still in use.

At first he lived at Blackheath, but in the later 1920's he migrated to Amersham, where, while continuing to serve at Kidbrooke, he settled down for the rest of his life in company with his father and his sister, for he never married. Both these relatives died before him, and during the last years of his life he lived alone except for his books and his many friends, to whom he frequently extended hospitality. Early in 1939 he retired from the Air Ministry, and thereafter devoted himself to his many hobbies.

Sloley was a widely travelled man, and in his earlier years had visited South Africa and India, for he had connexions with both countries. His interests outside his regular work included music and the arts (he became vice-president of the Chiltern Arts Club during his residence in Amersham); also science, general archæology and Egyptology. In this last subject he was particularly interested; he studied the Ancient Egyptian language for a year or two at University College, London, but his real interest was in Egyptian mathematics and science, and more particularly in Egyptian astronomy and methods of measuring time, on which topics he was probably better informed than any English professional Egyptologist. In November 1930 he delivered to the Egypt Exploration Society an admirable lecture on primitive methods of measuring time which was afterwards published in Vol. 17 of *The Journal of Egyptian Archæology*, and in 1942 he contributed the chapter on science to the volume, "The Legacy of Egypt", edited by the late Prof. S. R. K. Glanville. He also served for some years on the committee of the Egypt Exploration Society. He did a great deal of lecturing to schools and societies, and once in the days of 2LO broadcast a talk on "A Day in the Life of an Egyptian Schoolboy". His last contribution to Egyptian archæology was a brief note in Vol. 39 of the *Journal of Egyptian Archæology* on radio-carbon dating as applied to Egyptian antiquities. His interest in ancient science, however, was not confined to Egypt, but extended also to Babylonia, and even perhaps to India. Under his quiet manner lay an unusually wide culture, and he will be greatly missed by all who knew him. R. O. FAULKNER

Prof. George Fegler

AFTER a distinguished career in medical and biological research, George Fegler died in Cambridge on September 23 at the age of fifty-nine. In Poland, between the time that he received his medical degree (Warsaw, 1924) and the outbreak of the Second World War, he held a number of important research and teaching posts, and in 1939 had just been elected to the chair of physiology at Vilna when he was recalled to the Army. Afterwards he worked in Edinburgh, where, during 1941–46, he was professor of physiology in the Polish Medical School and took part in the war research programme of the University

Department of Physiology. In 1950 he was appointed principal scientific officer at the Agricultural Research Council Institute of Animal Physiology, at Babraham, a post which he held until his death.

His thirty-four years of research covered an unusually wide range of problems; but his greatest interest was in respiratory and cardiovascular physiology, and it was in connexion with problems in these fields that he had recently developed his thermodilution method for the measurement of blood-flow. The method is similar in principle to other indicator–dilution methods, notably the dye–dilution technique, but for certain purposes has a number of advantages over that method. Fegler himself used it successfully to determine cardiac output, renal and portal flow in the dog and sheep; other laboratories had shown considerable interest in the method and had requested his assistance in modifying it for other uses, notably as an aid to clinical investigation.

The method, while favourably received by some, was criticized by others, chiefly on theoretical grounds. Fegler met criticism by testing experimentally each point that had been raised, and extending his controls so that he could assert with confidence that the method fell within the same limits of error as other accepted methods. He also presented a reasoned analysis of the thermodilution curves which showed that perhaps his critics rather than he had strayed into error. But he took no pleasure in polemics. He examined all criticism carefully so as to be sure he had a reliable tool for the research which he had planned. Some progress in this work, a study of the normal shifts in blood-flow from different organs in relation to the metabolic demands of the body, had already been made by him. It is typical, however, that he was at the same time attempting to improve his methods, so that he could, on one hand, achieve more nearly physiological conditions of experiment, and on the other, come closer to that impossible goal of physiologists, an ideal method of measuring blood-flow.

To his colleagues, with whom he discussed these and other problems and who have in the past benefited so much from his experience and scientific knowledge, his loss is a very real one. CATHERINE O. HEBB

Mr. C. C. Mason, O.B.E.

MR. CECIL CHARLES MASON died suddenly on September 9 at the age of seventy-seven.

Mr. Mason graduated with a first in the Mathematical Tripos at Cambridge, and joined the Cambridge Instrument Co. in 1910. He was a joint managing director from that year until his retirement from executive work in 1941, and he remained on the Board until his death. Appointed O.B.E. for his work on shell fuses in the First World War, Mr. Mason was not only responsible for many other technical advances in the instrument field, but also made major contributions to the Company's growth through his wise administration and financial acumen.

Mr. Mason was respected by everyone, and his loss will be keenly felt by a host of friends.

NEWS and VIEWS

Atomic Energy Research Establishment, Winfrith Heath: Mr. D. W. Fry

IN 1956 the Atomic Energy Authority decided to build a new establishment of its Research Group. A site was chosen at Winfrith Heath in Dorset, and, after a public inquiry, the Authority was given permission to use it in 1957. Work is advancing rapidly on this new establishment, and the Authority has announced the appointment of Mr. D. W. Fry as the person responsible to the director of the Research Group for its development and the initiation of the programme.

Donald William Fry, who was born at Weymouth in 1910, was educated at Weymouth Grammar School and King's College, London. He worked in the General Electric Company's research laboratories for four years before moving to the Royal Aircraft Establishment, Farnborough, in 1936. There he took part in the development of very high-frequency communication equipment for R.A.F. Fighter Command. During 1940–45 he served in the Telecommunications Research Establishment on the development of microwave radar. Fry, and several of his colleagues, joined the staff of the Atomic Energy Research Establishment in 1946. This group, working in Malvern, demonstrated the practicability of the high-current linear accelerator and the electron synchrotron. Fry was awarded the Duddell Medal of the Physical Society in 1950. He became head of the General Physics Division at Harwell in 1950. The main work of the Division has been in the high-energy accelerator and thermonuclear fields. Fry was appointed chief physicist of the Atomic Energy Research Establishment in August 1954 and promoted to be a deputy director of the Establishment in February 1958.

Atomic Energy Research Establishment, Harwell

THE following staff changes at the Atomic Energy Research Establishment, Harwell, are announced by the United Kingdom Atomic Energy Authority:

Dr. J. V. Dunworth, formerly head of the Reactor Division, has been appointed assistant director (reactor research policy). In this post he will be special adviser to the director of Harwell. He is succeeded as head of the Reactor Division by Mr. T. M. Fry, who has been a deputy head of the Reactor Division.

Dr. Peter Thonemann, head of the Controlled Thermonuclear Reaction (Fusion) Division at Harwell, has been granted study leave for one year from March 1959. He will be going to the Institute of Advanced Studies in the University of Princeton, where he will work on plasma physics. In Dr. Thonemann's absence the Harwell fusion programme will be carried forward by his deputy, Mr. R. S. Pease, under the supervision of Mr. D. W. Fry, who is deputy director of Harwell with special responsibility for this work (see also preceding note). Dr. Thonemann will be available for consultation.

Physiology at the Medical College of St. Bartholomew's Hospital: Prof. K. J. Franklin, F.R.S.

THE news of Prof. K. J. Franklin's retirement from the chair of physiology at St. Bartholomew's Hospital has been received with much regret by his many friends and former pupils. Franklin went to Oxford after service in the First World War. He obtained a first-class degree in the Final Honours School of Physiology, studied medicine at St. Bartholomew's Hospital and returned to Oxford as a Fellow of Oriel College in 1924. He was a demonstrator in pharmacology from then until 1935 when he was appointed assistant director of the Nuffield Institute for Medical Research. He was dean of the Oxford Medical School for many years, and went to St. Bartholomew's as professor of physiology in 1947. Prof. Franklin was very interested in the venous side of the cardiovascular system, an interest which led in 1933 to collaboration with Prof. Janker, of Bonn, one of the pioneers of X-ray cinematography. When the Nuffield Institute for Medical Research was established in 1935, special provision was made for the study of X-ray cinematography as applied to medical problems. Within a few years Franklin's foresight was justified by the first experimental demonstration of the course of the fœtal circulation. This work, in collaboration with Dr. A. E. Barclay and Sir Joseph Barcroft, finally settled a controversy which had lasted for nearly two centuries, and also provided the first direct evidence as to the nature of the changes in the circulation after birth. In 1947 the same method applied to the kidney led to the publication of some exciting and controversial "Studies of the Renal Circulation" in collaboration with Trueta, Barclay, Daniel and Prichard. Apart from Prof. Franklin's interest in the venous system (a "Monograph on Veins" was published in 1937, and "Cardiovascular Studies" in 1948), his meticulous researches into the history of physiology and his facsimile editions and translations of early writers on the circulation have earned the gratitude and respect of his colleagues. Within the past two years he has followed these with admirable translations of Harvey's "De Motu Cordis" and "De Circulatione Sanguinis".

Prof. M. de Burgh Daly

PROF. Michael de Burgh Daly, who has been appointed to succeed Prof. K. J. Franklin in the University chair of physiology at St. Bartholomew's Hospital Medical College, is also particularly interested in the control of the circulation and respiration. After taking the B.A. degree in Cambridge in 1944, he proceeded to St. Bartholomew's Hospital and qualified M.B., B.Chir. in 1947. After a house appointment, he joined Prof. G. L. (now Sir Lindor) Brown in the Department of Physiology at University College, London, and began research with the late Alfred Schweitzer. His interests in circulatory and respiratory physiology stem to some extent from the influence of Schweitzer and from that of his distinguished father, Dr. Ivan de Burgh Daly, until recently director of the Institute for Animal Research at Babraham, who has made great contributions to these subjects. Prof. de Burgh Daly spent 1952–53 in Philadelphia as Rockefeller Fellow in Prof. Schmidt's department. On his return he was appointed Locke Research Fellow of the Royal Society. His research activity has been considerable and fruitful. Among a long list of papers, notable have been those on the baroreceptor regulation of cardiac output, on the blood supply and oxygen usage of the carotid body and on chemoreflex responses of the pulmonary circulation.

Botany at Edinburgh: Prof. R. Brown, F.R.S.

THE appointment of Dr. Robert Brown to the regius chair of botany in the University of Edinburgh, in succession to the late Sir William Wright-Smith, can scarcely fail to mark a new chapter in the history of botany in Scotland. The Department of Botany in Edinburgh has a long and honourable tradition of taxonomy, and Dr. Brown has achieved a notable reputation as a plant physiologist with a very individual outlook; his activities in this new sphere will be watched with the liveliest interest. His earlier work includes contributions to the study of the stimulation of germination in seeds of the parasite *Striga* by root exudates from the host; but the bias of his more recent researches has arisen from the development and imaginative exploitation of a powerful new technique for the estimation of cell numbers in growing-points and the tissues immediately behind them. The combination of a maceration technique with a hæmacytometer cell-counting method has made it possible to express the results of chemical and other estimations on a per cell basis. This has given the impetus to a remarkable series of studies of the development of cells from growing-points, carried out by Dr. Brown and his co-workers, first at Leeds and later (from 1953) in his very active Agricultural Research Council Unit of Plant Cell Physiology at Oxford. A brief summary of Dr. Brown's career appeared in *Nature* of October 11 (p. 992).

Pharmaceutical Society of Great Britain

A PORTRAIT of the late Prof. John Attfield, for thirty-four years professor of practical chemistry to the Pharmaceutical Society of Great Britain, was presented to the Society after the October meeting of the Council by his grandson, Mr. C. A. Brooks, of Dedham, Essex. The portrait is a replica of one given to Chicago pharmacists which was painted in recognition of the work done by Prof. Attfield in helping to "raise their College from its ashes after the Great Fire of 1871". With the portrait, Mr. Brooks handed to the Society a complete set of the nineteen editions of his grandfather's famous textbook of pharmaceutical chemistry and an album containing an illuminated address and 1,240 signatures of professional colleagues, including those of Lord Lister, Sir William Crookes and Sir Henry Wellcome. In accepting the gifts, Mr. Hudson, president of the Pharmaceutical Society, said they would be a perpetual reminder of the prominent place Prof. Attfield occupied in the Society's history and in the scientific world; and of the services he had rendered to pharmacy and to medicine. He served the Society from 1862 until 1896. Probably, said Mr. Hudson, Attfield's greatest achievement was his work for the "British Pharmacopœia"; and by the time of his death he had the satisfaction of knowing that it was legally adopted in all British Dominions.

Josiah Wedgwood and Research

IN his 1957 presidential address to the North Staffordshire Field Club, J. Leighton directed attention to letters written by the famous eighteenth century potter, Josiah Wedgwood, to his colleague, and later, partner, Thomas Bentley (*Trans. N. Staff. Field Club*, 91; 1958). The letters show how, in company with other Staffordshire potters, Wedgwood planned so early as 1755–56 a co-operative research establishment for the pottery industry.

Following a patents dispute, proposals were made that a joint stock experimental company be established for the purpose of the general improvement of the manufacturers' products. Among the Wedgwood papers are the committee's "Heads of an Agreement, etc.", the first of which runs: "Proceedings in the scheme of an Experimental Work. The Commee. were of opinion that all who had subscribed to the opposition etc. shod. have a choice of becoming Members of a Company for carrying it into execution, and they were invited by circular letters, in consequence of which, they will meet on Tuesday next, when will be laid before the following Heads of an Agreement to be entered into. . . . We do mutually agree to establish an Experimental work for the purpose of trying the materials lately brought from Cornwall, as well as those which may in future come from that County as any other place in order to improve our present manufacture and make an Useful White Porcelain Body, with a colourless glaze for the same and a blue paint under the glaze. It was also proposed that no member shall disclose the experiments made by this Company or the knowledge obtained by them to any person or persons not in the Company, on pain of forfeiting his share in the joint Stock, and of incurring a penalty of One thousand pounds and that no one of us shall take advantage of the knowledge acquired by the experiments of this Society, by adopting any of the improvements made thereby in our own private manufactories or otherwise, until the plan and time of generally adopting and removing such improvements into the manufactory at large to be agreed upon by the Society under the penalty of One thousand pounds".

Unfortunately the plan came to nothing, but Wedgwood went on to write: "Having done my duty I am contented, and shall take my own course quietly by myself as I can, and may perhaps have it in my power to serve the trade some other way. . . . I shall now begin with the materials in earnest. I scarcely thought myself at liberty to do so whilst the Partnership plan was in agitation".

Historic Aircraft Maintenance Group

A GROUP of volunteers composed of members of the Royal Aeronautical Society and of the Society of Licensed Aircraft Engineers is about to begin work on repairing and maintaining the aircraft of the Nash Collection of historic aircraft now owned by the Royal Aeronautical Society. Since it acquired the Nash Collection in 1954, the Royal Aeronautical Society has had many difficulties in the storing and housing of the aircraft, but recently a hangar at the R.A.F. Station, Hendon, was made available. An appeal for volunteers living in the London area to work on the aircraft, made by the secretary of the Society in July this year, met with an enthusiastic response. Members of the two Societies are now starting work, giving up their week-ends to get these historic aircraft back to display condition. Captain E. D. Ayre, a past president of the Society of Licensed Aircraft Engineers, has been appointed chief engineer of the Historic Aircraft Maintenance Group. He has already undertaken a preliminary inspection of the aircraft and has started to collect the necessary equipment. Captain Ayre will supervise a team of engineers who have had extensive practical experience on the types of aircraft and engines in the Nash Collection. The guiding principles will be preservation rather than renovation, so ensuring that the craftsmanship of an earlier generation is not lost. It is hoped that, ultimately, the Society's Nash Collection will form part of a National Collection of Aircraft.

The Border Country in Britain

THE Forestry Commission's decision to declare the Border Country the eighth national forest park of Great Britain will give pleasure to all who have watched the planting, growth and development of the Forests of Kielder, Wark, Redesdale, Kershope, Newcastleton and Wauchorpe during the past thirty-five years. Their pleasure will be enhanced by the publication of a national forest park guide which worthily maintains the high standards of its predecessors (The Border. Edited by Prof. John Walton. National Forest Park Guides. Pp. vi + 94 + 16 plates. London: H.M. Stationery Office, 1958. 5*s*. net). The bulk of the guide consists of accounts by H. L. Edlin of the land, the people, the poetry and legend of the Border, the Border forests and walks most likely to bring pleasure to nature-lovers. The Border region in Roman times is described by Prof. I. A. Richmond, and the history is continued by Prof. J. D. Mackie. Dr. W. A. Clark discusses the vegetation of the park, and Ernest Blezard the wild-animal life. The geology of the region is examined by Dr. G. A. L. Johnson. An extensive bibliography has been carefully built up by three prominent librarians. There is also the usual and indispensable section called "General Information"—which will help those who are new to the area to find their way about more quickly, profitably and, where appropriate, economically. Splendidly illustrated with verse, black-and-white sketches, photographs and maps, the guide is excellent value at 5*s*. The Forestry Commission and, particularly, Mr. Edlin deserve the highest praise for the quality of these publications.

Recent Phycological Publications

THE attention of readers interested in the problems of the algae may be directed to the *Phycological Bulletin* (No. 6, June 1958, pp. 1–53, issued by the British Phycological Society; *President*, Dr. J. W. G. Lund; *Hon. Editor*, Dr. Elsie Conway, Department of Botany, University of Glasgow). This issue gives a clear indication of the officers, construction and aims of the Society, namely, to pursue the scientific study of marine and freshwater algae on the widest basis. The contents include tributes to the late Dr. Kathleen M. Drew, who did so much to further the study of these organisms and to found the Society, abstracts of papers read at the London meeting in January 1958, and a variety of topics of both general and special interest to algologists. In particular, reference should be made to important tables of chromosome numbers in the Ulotrichales and in the brown algae, the authorship being cited in each instance. A volume of abstracts of the third International Seaweed Symposium, held in Galway, Eire, in August 1958, has also come to hand (pp. 1–82; University College, Galway). Some seventy-one papers, covering a very wide field, were submitted. These include such topics as biophysical and biochemical aspects of some algae, the possibilities of the mass culture of microscopic marine algae, their utilization as sources of raw materials, cytological and ecological studies, and so on. Yet a further contribution to algology comes from the Nova Scotia Research Foundation. This consists of a "Selected Bibliography on Algae" (No. 4. Pp. 1–109. Halifax, Nova Scotia), and includes references to chemical and physical studies, culture, ecology, physiology, biology, morphology, taxonomy and utilization.

The World Health Organization

"An International Nomenclature of Yaws Lesions", by Dr. C. J. Hackett, in co-operation with an international group of experts and participants of the international conference on yaws control held at Enugu, Nigeria, in 1955 (World Health Organization Monograph Series No. 36. Pp. 103. Geneva: World Health Organization; London: H.M. Stationery Office, 1957. 12 Swiss francs; 20*s.*; 5 dollars), is an outstanding contribution to the study of the disease called, in English, 'yaws', in French 'pian', in German and Dutch 'frambœsia', in Spanish 'buba', and in Portuguese 'bouba'. The various names used in the study of the disease are defined, and the stages in the disease are described. There are seventy-six plates showing the frightful lesions caused by the spirochæte, *Treponema pertenue*, which is responsible for the disease. Some of these show the remarkable healing without scarring that may follow a single injection of penicillin. The nomenclature supersedes the earlier one given in the World Health Organization Monograph Series No. 5, entitled "Atlas of Frambœsia", by K. R. Hill, R. Kodijat and M. Sardadi, published in 1951. The successful reduction of yaws and the campaigns against it sponsored by the Organization and by UNICEF are described in "The First Ten Years of the World Health Organization" (pp. viii + 540 + 28 pages of photographs. Geneva: World Health Organization; London: H.M. Stationery Office, 1958. 25*s.*; 5 dollars; 15 Swiss francs), which gives a comprehensive survey of its achievements in the many fields of health control and eradication of disease in which it operates all over the world. Another account of its achievements, illustrated by remarkable photographs of the work actually in progress, and attractively written by Ritchie Calder, is entitled "Ten Steps Forward, World Health 1948–58" (London: H.M. Stationery Office, 1958. 2*s.* 6*d.*).

Health in the Tropics

The report of the thirty-second meeting of the Ross Institute Industrial Advisory Committee on June 19 (pp. 19. London: London School of Hygiene and Tropical Medicine, incorporating the Ross Institute, 1958) records the address given by Dr. Alan Gilroy, principal of the India Branch of the Institute, and the subsequent discussion. Dr. Gilroy referred to the progress made in regard to malaria. In a large sample of tea-estate labour there were 12 cases of malaria per 1,000 in 1957, no deaths, and a spleen rate of only 1·5 per cent. As a result, with the adoption of a malaria-eradication programme by the Government of India, the industry could now contemplate relief from its recurring expenditure of nearly thirty years. Anæmia remained a most important cause of ill-health, and about 90 per cent of the cases are of simple iron-deficiency anæmia, although the diet was not short of iron and patients were not losing it to hookworm. In replying in the discussion, Dr. Gilroy said that the scientific investigation of malnutrition was as yet incomplete, but it appeared that although the diet was adequate in quantity it was deficient in quality. This was due to ignorance rather than to lack of purchasing power. Dr. Gilroy also said that the stage had been reached when it was accepted and recognized that family planning was necessary, and he also referred to the lecture courses in tropical hygiene for planters and the refresher courses held for tea-estate assistant medical officers.

City and Guilds of London Institute

The rapid growth of technical education in Great Britain and overseas is well brought out in the seventy-eighth annual report of the City and Guilds of London Institute, for the year October 1, 1956, to September 30, 1957 (Pp. v + 118. London: City and Guilds of London Institute, Gresham College, 1958). In 1957, 119,948 students took one of the great variety of courses arranged by the Institute compared with 105,815 in 1956; it is not surprising to learn that 62·5 per cent of students in Great Britain and Ireland were successful in their examinations, whereas the number of successful overseas students was 48·1 per cent. Of the students, almost half of them (54,391) took courses in electrical subjects, 21,715 courses in mechanical engineering, 18,640 in building subjects, and 9,378 in chemistry subjects. Other courses taken were in domestic subjects, printing and food technology. Many of the courses were revised during the year and a number of new ones were added; among the latter is a course for a National Certificate in Agriculture for students who have completed a year at a farm institute. The report also contains details of the insignia awards in technology, the work of the art school and the City and Guilds College, as well as the response to examinations set by the Associated Examining Board for the General Certificate of Education.

The Cosmic Distance Scale

In his Warner Lecture before the American Astronomical Society, Dr. Allan Sandage has reviewed the current status of work on the cosmic distance scale (*Astrophysical Journal*, 127, 513; 1958; *Sky and Telescope*, 17, 275; 1958). Hubble's criteria for setting up the distance scale have been re-examined. He used the brightness of the cepheid variable stars in the Andromeda and Triangulum nebulæ, the brightness of individual high-luminosity stars for somewhat more distant galaxies, and integrated apparent magnitudes of still more distant objects. The first criterion was revised in 1952 when Baade showed that classical cepheids were 1·5 magnitudes brighter than had been supposed: this effectively doubled the scale of distances. Other complicating features have since been discovered: the period-luminosity 'curve' seems to be a broad band, and new methods will have to be devised to find out whether individual cepheid variables are under- or over-luminous for their periods. One can therefore scarcely rely on the cepheid criterion for the thirty galaxies in which these stars can be seen with the 200-in. telescope.

Sandage has shown that Hubble's second criterion was incorrectly applied, in that many of the objects which Hubble believed to be bright stars were in fact ionized hydrogen regions; their nature only became evident when photographs were obtained through Hα filters. In the nebula M 100, for example, objects at magnitude 19·0 are ionized hydrogen regions, not stars, the brightest stars appearing at magnitude 20·8. If these individual stars have absolute magnitudes of − 8·5, the distance of M 100 would be about six times its value on the 1936 distance scale; the Hubble constant of recession would be 87 km./sec./megaparsec. A similar result follows from studies of the globular clusters in the nebula *M* 87. These arguments do not constitute a rediscussion of the distance scale. Precise new measurements are required for this, and such measurements are now in progress at Mount Palomar.

Atoms for Peace Conference: American Publication

AT the second International Conference on the Peaceful Uses of Atomic Energy recently held in Geneva, a set of twelve volumes dealing with the American participation, written expressly for the Conference and containing much information just declassified, was presented to official delegates as a gift from the United States. These volumes have now been published by Addison-Wesley Publishing Co., Inc., Reading, Mass., on behalf of the U.S. Atomic Energy Commission. (The volumes are also obtainable from Academic Books, Ltd., 129, Queensway, London, W.2.) The price of each separate volume varies from 45*s*. 6*d*. to 92*s*.; but the complete set is available at £30. Further information can be obtained from either the Addison-Wesley Publishing Co., Inc., or Academic Books, Ltd., at the above addresses.

Mammal Society of the British Isles

A SYMPOSIUM entitled "Mammals in British History and Prehistory" will be held in the meeting room of the Zoological Society of London, Regent's Park, on November 1. Non-members of the Society are invited to attend; there is no registration fee. The programme will include talks on the conditions for the preservation of mammalian remains, and blood grouping of human remains; the mammalian fauna and environmental conditions at the close of the Pleistocene; the mammalian fauna from Star Carr; and the historical development of farm animals in relation to their environment. Further details can be obtained from the conference secretary, Dr. K. M. Backhouse, Charing Cross Hospital Medical School, 62–65 Chandos Place, London, W.C.2.

Torry Research Station

THE Council for Scientific and Industrial Research announces that responsibility for the research programme of the Torry Research Station at Aberdeen will be vested in a steering committee, consisting of: Dr. B. K. Blount (*chairman*), deputy secretary of the Department of Scientific and Industrial Research; Mr. G. C. Wilson, a member of the White Fish Authority and the Herring Industry Board; Dr. D. Traill, director of research of the Nobel Division of Imperial Chemical Industries at Stevenston, Ayrshire; Mr. H. Wooldridge, head of the Stations Division of Headquarters, Department of Scientific and Industrial Research; and the director of the Station, Dr. G. A. Reay. Dr. Reay's title was formerly 'superintendent', but it has now been changed to 'director'.

Announcements

MR. J. WILSON has been awarded the Hinchley Medal of the British Association of Chemists for 1957. The formal presentation will be made at the Royal Society of Medicine (West Hall), 1 Wimpole Street, London, W.1, on October 29, at 7 p.m. Mr. Wilson will then deliver the Hinchley Memorial Address, which is entitled "Grant-aided Research Associations".

MR. ALEC M. HUGHES, general secretary of the Scientific Film Association, has been appointed visual aids officer of the British Association for the Advancement of Science.

MR. A. P. GAGNEBIN, who has been elected a vice-president of the International Nickel Company, Inc., joined the Company's research laboratory at Bayonne, New Jersey, in 1932 and devoted himself to research on ferrous metals. He became a member of the Ductile Iron Section of the International Nickel Company's Development and Research Division in 1949, where he was active in the industrial development of ductile iron, of which he is a co-inventor. In May 1952, Mr. Gagnebin was a co-recipient of the Peter L. Simpson Gold Medal of the American Foundrymen's Society, for outstanding work and development in the field of ductile iron. He is the author of many technical papers and of the book, "The Fundamentals of Iron and Steel Castings".

THE British Council (65 Davies Street, London, W.1; telephone, Grosvenor 8011) asks senior academic scientists who are contemplating overseas tours (other than to the United States) to inform it of their intentions. The Council can often help with specialist contacts—and can sometimes arrange lectures by the traveller—in the countries to be visited or *en route*. Such collaboration is greatly valued by the Council as an important contribution to its efforts to promote a wider knowledge overseas of the sciences in Britain. Communications on this subject can be addressed to the Director, Specialist Tours Department.

THE winter conference of the Physical Society, on physics of the solid state, will be held in the Cavendish Laboratory, Cambridge, during December 18–20. The subject of the conference will be interfacial phenomena, and it is hoped that papers will be given on some or all of the following subjects: (1) structure of vacuum-evaporated layers on single-crystal substrates; (2) structure of electrodeposited layers; (3) epitaxy; orientation of crystals on various substrates; (4) grain boundary phenomena; the interface between different phases in metals; (5) the interface between solid and liquid phases. Those wishing to take part are invited to write to Prof. N. F. Mott, Cavendish Laboratory, Cambridge.

THE fourth Congress on Theoretical and Applied Mechanics will be held under the presidentship of Dr. S. R. Sen Gupta at the Bengal Engineering College, Howrah, Calcutta, during December 28–31. Research papers may be contributed on any of the following topics: (1) elasticity, plasticity, rheology; (2) fluid mechanics (aerodynamics, hydrodynamics); (3) mechanics of solids (ballistics, vibrations, friction-lubrication); (4) statistical mechanics, thermodynamics, heat transfer; (5) mathematics of physics and mechanics; and (6) experimental techniques. Registration forms and further information can be obtained from the Secretary-Treasurer, Indian Society of Theoretical and Applied Mechanics, Indian Institute of Technology, Kahragpur, India.

ERRATUM. Reference was made in the article entitled "Academic and Professional Mobility" in *Nature* of August 16, p. 413, to a paper by Dr. P. E. Weatherley; we regret that his name was wrongly spelled in that article and also in an earlier article (*Nature*, 181, 677; 1958).

ATMOSPHERIC DIFFUSION AND AIR POLLUTION

AN international symposium on "Atmospheric Diffusion and Air Pollution", arranged jointly by the International Union of Theoretical and Applied Mechanics and the International Union of Geodesy and Geophysics, was held in Oxford during August 24–29. The symposium brought together from various countries nearly one hundred scientists, mainly meteorologists and fluid dynamicists, with active interests in one aspect or another of the physics of turbulent diffusion. The scientific programme was planned by a committee under the chairmanship of Sir Geoffrey Taylor and the joint secretaryship of Dr. F. N. Frenkiel (Johns Hopkins University) and Prof. P. A. Sheppard (Imperial College of Science and Technology, London), and was expressly designed to examine outstanding basic problems in the study of atmospheric diffusion and its application to air pollution studies. Accordingly, after an opening session which included broad surveys of the distribution and effects of the airborne products of combustion, conventional industrial processes and nuclear processes, the proceedings were organized into sessions dealing with specific aspects of the problem of diffusion. These included the structure of atmospheric turbulence, the theoretical treatment of the diffusion of particles in a turbulent atmosphere, the processes of vertical transfer on all scales in the atmosphere and the effect of thermal stratification thereon, and the distribution of airborne material from artificial sources.

As nearly forty papers were presented, this article would be little more than a catalogue if all were to be mentioned individually. For such detail the reader will shortly be able to turn elsewhere, for the entire proceedings of the symposium, both papers and discussions, are to be published in book form by Academic Press, Ltd., and it is hoped that they will appear before the end of the year. The aim of this article is rather to comment on some of the major issues brought out in the proceedings.

The scientific treatment of atmospheric diffusion was effectively started by Sir Geoffrey Taylor in 1915 in his classical work on the vertical transfer of heat and momentum by eddies in the atmosphere. This work was the beginning of one of the two main approaches to the subject, the approach which is concerned with the 'bulk' properties of the fluid, especially the gradients of the mean properties undergoing diffusion, as distinct from the other main approach involving preoccupation with the internal structure of the fluid. The real beginning of this latter approach was also provided by Taylor, in 1921, in a paper in which diffusion was related to the correlation between the eddy velocities of a given element of fluid at specified times. Then in 1926 L. F. Richardson put forward a novel theory of atmospheric diffusion which implicitly recognized the existence and importance of a whole spectrum of eddy sizes in turbulent motion. More explicit use of the idea of a spectrum came later, at first in a purely formal sense, in the general theory of the statistical mechanics of isotropic turbulence, initiated by Taylor in 1935 and followed up more recently by G. K. Batchelor and others. From a physical point of view, an important step in the development of the concept came with A. N. Kolmogoroff's set of simplifying hypotheses concerning the transfer of turbulent energy from large eddies to small eddies. Although these ideas were put forward in 1941, owing to the Second World War they did not begin to be widely known until nearly ten years later. The fundamental ideas involved in these earlier advances still dominate the background against which the Oxford discussions were conducted.

The contributions on the structure of atmospheric turbulence all indicated the tendency, which has grown rapidly, especially over the past five years or so, to represent this turbulence on the statistical basis which has been so highly developed in the study of wind-tunnel turbulence. Owing to the large range of eddy sizes normally present in the atmosphere, the emphasis has naturally been more on the spectrum of eddy energy than on the time- or space-correlations of the velocity fluctuations, though in practice the time-correlations (from velocity observations at a fixed point) are obtained as an essential intermediate step. The 'power-spectra' derived from them by Fourier transform techniques give the intensities of the contributions, to the total variance of the velocity component, from oscillations of particular frequencies which are contained in the time-variation of the component. These 'time-spectra' are strictly to be distinguished from the so-called Eulerian 'space-spectra', which are correspondingly derived from simultaneous velocity measurements at many fixed points, and which contain a more satisfactory physical representation of the eddy 'size'. However, it has been customary for some time to assume equivalence of the more easily obtained 'time-spectra' with space-spectra in the direction of the mean motion, and evidence on this continues to accumulate.

Two features which were brought out concerning the shape of the spectrum are especially worthy of mention here. If the spectra for the vertical component at heights varying from one to a few hundred metres are 'normalized', by plotting the product of the equivalent wave-number (the reciprocal of the wave-length) and the spectral intensity against the product of the wave-number and the height, there appears to be a general similarity in shape, with a maximum intensity at a wave-length of the order of three times the height above ground. The other features concern behaviour at higher frequencies, where, according to the ideas put forward by Kolmogoroff, all forms of turbulence should exhibit isotropic properties, that is to say, properties which are unaffected by rotation of the axes of reference. The data now accumulating leave no doubt that the limiting eddy size, below which the isotropic structure exists, increases with increasing height above ground, and recent measurements confirm an earlier suggestion that the isotropic limit occurs at an equivalent wave-length approximately equal to the height. Both of these generalizations may well require some qualification when appreciable thermal stratification of the atmosphere is involved, but they represent useful first steps in the provision of an integrated description of atmospheric turbulence.

In the papers relevant to the vertical transfer of momentum and heat in the lower atmosphere, it was encouraging to see the Navier–Stokes equations of fluid motion being used as a starting point for understanding some of the stages in the complex cycle of energy exchange in stabilized and unstable flow. On the other hand, it was evident that some confusion still exists in the empirical description of the effects of thermal stratification. All seems reasonably straightforward so long as the atmosphere is in neutral or near-neutral equilibrium, when the adoption of the familiar universal wind profile (wind velocity varying with the logarithm of the height) enables the flux of momentum (and of other properties) to be usefully estimated merely from measurements of the vertical gradients of wind velocity and of the properties concerned. The long-required extension of this sort of treatment to the cases when the atmosphere is heated or cooled from below has recently seemed to be forthcoming from dimensional analysis. These treatments certainly lead to wind profiles of the required shape in stable and unstable conditions, and also to the correct qualitative variation of vertical flux with degree of stability, but at this point the consistency appears to end. In the first place, there are important differences, which have yet to be explained, in independent measurements of the vertical transfer of momentum near the ground. Furthermore, it seems that the magnitudes of the dimensionless parameters required by the form of the wind profile are of a different order from those required to explain the absolute magnitude of the vertical flux. Since one of the practical interests lies in being able to estimate flux quantities from profile measurements, these discrepancies are frustrating as well as puzzling, and their resolution would represent an advance of some practical importance.

It may be that the resolution of these difficulties will only come as a result of closer attention to the structural properties, as in one of the contributions, where for two specific cases with unstable conditions it was demonstrated that the vertical motions responsible for heat transfer were of larger scale than those responsible for momentum transfer. Moreover, from a number of points there are reminders that with increasing instability and with increasing height above the surface boundary the dominant character of the vertical motion changes from that of mechanically generated turbulence to the more organized motions of thermal convection. Some progress has already been achieved in the representation of the heat transfer by these organized motions, but a useful statistical derivation of the transfer of momentum and other properties has evidently yet to emerge.

In the theoretical treatment of the distribution of particles released in a turbulent fluid increasing use is now being made of the mathematical and statistical techniques which were evolved largely in relation to aerodynamic problems. Many of the developments are still in a highly formalized stage, and the progress made towards rigorous solutions which can be expressed in terms of measurable properties of the turbulence is not immediately obvious. However, one real improvement is to be noted in the more detailed attention which is being paid to the significance of the finite time involved in observing diffusion phenomena. The need for this attention arises directly from the 'width' of the turbulence spectrum, and becomes the more pressing in the case of atmospheric flow, where for many problems the spectrum extends effectively indefinitely into the region of long wave-lengths. Another welcome sign is the increasing recognition of the distinction between the distribution of particles relative to fixed axes after continuous release from a fixed point, and the relative spread of particles released instantaneously in a cluster. These ideas are being adopted to an encouraging degree in a 'model' treatment of the statistical properties of the continuous plume from a fixed source of particles. The accumulation of satisfactory observations on the relative spread of particles is now an outstanding requirement.

Despite these more advanced exploitations of the statistical theories of turbulence, a central problem still remains in the interpretation of the Lagrangian variations of the motion, that is to say, the variations in the velocity of a particle in contrast to the variations which may easily be observed at fixed points in the fluid. This problem was presented from the beginning in Taylor's 1921 analysis, by which the diffusion from a serial release of particles is specified in terms of the Lagrangian correlation coefficient, namely, that between the velocities of a particle at successive instants of time. The gap between this virtually unmeasurable property and the measurable time or space correlations at fixed points has yet to be bridged, and the fluid dynamicists are not yet able to offer any hope of this being achieved soon in the circumstances of concern to the meteorologist.

In the absence of a tractable analytical relation between these Lagrangian and Eulerian properties the realization of the practical end-point in the present subject, that is, the formation of realistic estimates of the distribution of airborne material released in a specified fashion, continues to lean heavily on empirical devices or careful limitation of the physical conditions involved. The latter recourse seems to be used with promising effect in contributions to the diffusion of falling particles with terminal velocities of a limited range, large enough to ensure that Eulerian variations are dominant over Lagrangian variations, yet small enough to exclude serious inertial effects on the response of the particles to the turbulent fluctuations. For floating particles some immediate progress is provided by the empirical step of assuming a simple relation between the Lagrangian correlation function and the auto-correlation function measurable at a fixed point. This has led to a method of obtaining the spread from a continuous point source directly and simply from measurements of velocity fluctuations.

The attainment of rational, albeit empirical, formulæ and methods for predicting diffusion is still mainly confined to the small-scale processes involved in diffusion over a few hundred metres. On the largest scale, involving exchange within and between the troposphere and stratosphere, the position is still one of gaining experience from the behaviour of natural and man-made tracer elements. Much interesting information is accumulating from measurements of fall-out from nuclear tests, and some of this is thought to fit in with current ideas of stratospheric motion based on studies of water vapour and ozone. Another promising radioactive tracer has been recognized in the isotopes produced by cosmic radiation. These have the advantage of being produced practically independently of time and without seasonal or diurnal changes. For the intermediate scale of diffusion, the sort involved in the travel of radioactive material from the Windscale reactor accident in October 1957, little progress has been reported. On this scale, involving heights of several thousands of feet and distances of tens of miles, the processes of dispersal are further complicated on one hand by the variation of the mean wind field with height, and on the ot large-scale effects of thermal stra alternatively to the virtually compl vertical spread or to rapid ascent vective motion. From a practical to this scale of processes that urgently required.

FUTURE OF MINERAL EXPLORATION IN GREAT BR AND IRELAND

THE fourth Sir Julius Wernher Memorial Lecture of the Institution of Mining and Metallurgy was given by Mr. Anton Gray, mining adviser to the U.K. Atomic Energy Authority, at the Royal Institution on September 22, his subject being "The Future of Mineral Exploration". In a survey of the world situation, Mr. Gray maintained that whereas it is unlikely that the present rapid rate of increase of consumption of metals can be maintained, it would not be surprising if the demand for the major metals doubles before the end of the present century. About the beginning of this century the geologist began to take over the work of the prospector, for by then most of the mineral deposits not concealed by younger formations had been found. But he has not had the same success in the search for a method of predicting the occurrence of ore-bodies as his colleague in the petroleum industry has had in finding concealed oil-pools.

This results from his inadequate knowledge of the precise mode of origin of mineral concentrations; for while it is generally agreed that most important ore-bodies were introduced into openings in pre-existing rocks by warm waters, there is no agreement as to the source of the water or of the contained metals. The dominant hypothesis, that of hydrothermal solutions related to granite, had been shown, in Mr. Gray's view, to be adequate only for a limited group of metals, including tin, tungsten, beryllium and some gold concentrations. He suggested an unorthodox but not heretical alternative for the other metals: that the waters are generated during metamorphism associated with mountain-building, and he based this suggestion on two of the great ore deposits of the world, the central African copper belt and the Witwatersrand goldfield. The great part which Mr. Gray has played in mineral exploration in central Africa lends authority to his advocacy of this hypothesis of what might be called metamorphic lateral secretion.

This lecture formed a prelude to a symposium on "The Future of Non-Ferrous Mining in Great Britain and Ireland", held at the Federation of British Industries on September 23–24. The symposium consisted of twenty-four papers, in three broad groups: a series of seventeen devoted to descriptions of the geology, mining history and potentialities of the mineralized districts of Ireland, Scotland, England and Wales; a group of short contributions on technical aids to mineral exploration, such as the various geophysical methods, the use of geochemical prospecting techniques and of air photography; and a series on economics and finance.

The foundation for an approac problems of the mineral fields w past century by the official prima Survey of Great Britain and Irel decline of the tin, copper and lea little further interest in the subj The Special Reports on Mineral Geological Survey, chiefly based on the First World War, brought toget data, but it is probably fair to s investigation by modern methods to the past two decades. The group gave a fair conspectus o reached. As is well known, the m British Isles occur in granite and a Carboniferous slate in the south-w England; and elsewhere chiefly in ments, the Lower Palæozoic slates metamorphics; and the unmeta Carboniferous rocks, chiefly of lime facies. A stratigraphical control– strict relationship between partic logies and introduced mineral bo by W. J. Hughes in central Wale in north Wales, and by H. G. Di shire, in all these cases in Lower but in other districts where the r age, such as the Lake District Leadhills–Wanlockhead (R. A. control has been found. Thus, w though steeply inclined, tend to be where they are related to the st they are not—as, for example, in or Coniston copper mines—the tw tend to be roughly equal. In the of the Pennines and Flint–Denbi well-marked relation to brittle b stone and limestone, as well as to wallrocks such as limestone and influence of impermeable or sem or rotted lavas overlying favour portant in localizing ore-bodies. these districts, as well as in man fields, ore-bodies occur which fail of these have been found by unde but nearly all districts contain prospecting for concealed mineral them of substantial promise. Th for the view that British metalli far from exhausted.

A second line of geological ap of the spatial distribution of individual districts. The zonal is well known and has been clarified by Dines, as well as in K. F. G. Hosking and J. H. Trounson's contribution to the symposium. Zoning has been demonstrated in the northern and southern Pennines by the present writer, broadly corresponding with the outer zones of Cornwall, but lateral rather than vertical in effect. It can be discerned in individual deposits like Bridford, Devon, described by P. G. L. Vipan, in a downward change from barite to sulphides, and Archer notes a broad though probably not genetic zoning in north Wales.

Most important of all, the localization of introduced mineral deposits is controlled by structural features, particularly by fractures which resulted from successive periods of stress and which form a definite pattern in each field; but also by granite cupolas, by folds of various dimensions and even by pre-ore dykes. At Leadhills–Wanlockhead a thrust plane is recognized as the operative control by Mackay. Displacement of ore-bodies by faulting after emplacement also occurred in many districts; in the northern Pennines this may have thickened some oreshoots locally. For Derbyshire it was suggested by W. W. Varvill that definite belts of rich mineralization, oblique to the superficial structure, could be recognized; perhaps these are related to trends in the concealed basement rocks.

Though more detailed structural information is desired in every district, the chief obstacle to successful prediction is present ignorance of the origin of the mineralizing fluids and their paths of ascent. A clear genetic relation to granite is demonstrable only in the south-west of England, and here it is interesting to note that Hosking's interpretation of the form of the granite batholith in depth, based on the distribution of mineral veins, corresponds remarkably closely with the quite independent interpretation based on gravity survey recently presented to the Royal Society by M. H. P. Bott, A. A. Day and D. Masson-Smith. There is evidence of concealed granites beneath the northern Pennines from the gravitational data of Bott and Masson-Smith, but the connexion with mineralization remains to be proved by deep boring. In many other districts, no hint has so far been found of such a connexion. There is, however, evidence from boring that mineralization persists to much greater depths than mining has so far reached, for example at Halkyn, described by G. A. Schnellmann, and east of the north Derbyshire district.

The geological age of the deposits has little bearing on their future value, but it is to be noted that on this aspect some new evidence was forthcoming. A. Fowler showed that the Conlig lead vein near Belfast follows a dolerite dyke of probable Tertiary age; while conversely Archer found that a dyke of the same age cuts through a lead lode at Parc in the Conway valley.

The mineral deposits of the Republic of Ireland, described by M. V. O'Brien, include at Avoca a deposit in Lower Palæozoic slates which has been developed with success in recent years, and which promises to be a major source of copper ore and pyrite. This work, financed by the Government and leading to the revival of a dead industry, exercised a considerable influence upon the discussions at the symposium. The small non-ferrous mining industry in the United Kingdom could be expanded if, using the geological basis which is now becoming available, techniques such as electromagnetic and shallow seismic survey, and geochemical soil sampling, were followed up by vigorous boring programmes. J. S. Webb's work at Gregory in Derbyshire showed how a lead deposit, deeply concealed under shale and grit, yet betrayed its presence by a leakage-dispersion at surface. The hope for the future is in the 'concealed areas', a conclusion emphasized by A. J. P. Walter.

The papers contributed to the symposium were available as pre-prints, but a collected volume, including the discussion, is to be published.

K. C. DUNHAM

THE NATIONAL STANDARDS LABORATORY OF AUSTRALIA

DIVISION OF METROLOGY

THE work described in the annual report for 1956–57 of the Division of Metrology of the Australian National Standards Laboratory extends over a wide field and is of interest to the physicist and the engineer, to the laboratory worker and the industrialist, who are concerned with standardization and fine measurement. The primary objects of the work are the maintenance and improvement of the Commonwealth standards, the development of improved techniques of measurement and providing assistance to industry. The need for standardization and co-operation at international level is clearly recognized and accepted as an important responsibility; considerable effort has been devoted to this end, particularly in the field of length-measurements by the up-to-date techniques of optical interferometry. It has involved world-wide travel to participate personally in deliberations under the auspices of the International Committee of Weights and Measures and of the International Convention for Legal Metrology, and to make personal contact with those engaged in similar work in comparable institutions in other parts of the globe. Incidentally, the report from the section which deals with line standards indicates very clearly the difficulties of establishing and maintaining precise standards of length on the present basis of a material metre bar in the custody of an institution half the world away. Australia will stand to gain as much as any nation from the international adoption, envisaged for 1960, of a wave-length definition of the metre.

In this brief note one cannot hope to do full justice to the many activities reported, and the remaining comment will therefore be confined to a few points. For example, it is noticed that the National Standards Laboratory has been able to extend its help beyond the borders of Australia in the verification of standards of mass and that its own accuracy of weighing, already high, is to be refined by means of a special balance ordered for the purpose. The fact that the section leader responsible for this work is also concerned with such diverse matters as barometry, density, photogrammetry, measurements of time and fluid flow and the investigation of lapping techniques illustrates the breadth of the need for precise measurement and development in basic techniques.

In the general field of engineering dimensional metrology, assistance is given to industry by testing measuring equipment of all types, machine tools and workpieces, by advice on the design of precision measuring apparatus, and by providing practical help in the alignment of large-scale engineering structures. The air gauging technique is being applied to the development of special measuring equipment.

Other needs of the engineer receive the attention of the Applied Mechanics Section, which is responsible for the measurement of force (load), pressure and hardness, and conducts research in vibration, engineering design, production processes and the mechanical aspects of machining. This Section is equipped for the measurement of load up to 500 tons-force in compression and 50 tons-force in tension, for the measurement of hardness in the usual scales, and has deadweight pressure gauge testers ranging up to 30,000 pounds-force per square inch.

Particular attention has been paid to the factors governing the functional requirements of an engineering product in relation to production and inspection, and the results of analytical study of these factors are being widely disseminated by publication and lecturing. In parallel, and in support, research is being conducted to determine the factors in machining which control dimensional frequency distribution, tool wear and tool life.

A small but active Electronics Section has been busy applying electronic techniques to a variety of problems such as a pressure controller for barometry and the measurement of the periodic errors in machine tools and of cutting forces in research on machinability. It is to be expected that this Section will be expanded in due course in order to reap more fully the advantages in accuracy and flexibility which electronic techniques can bring to precise measurement.

Returning to the subject of vibration, it is recorded that the demand for vibration testing and consultative services have seriously reduced progress on main research projects and that certain of the Division's equipment has had to be moved to a site shown by a vibration survey to be less objectionable. The simultaneous growth of the need for more powerful machines and equipment and for greater refinement of measurement presents a growing problem of particular importance to all metrologists, a problem which will become increasingly difficult to solve without forethought on the part of all concerned.

The staff of about three dozen research officers and technical officers, helped by an equal number of technical assistants, during the year published nearly a dozen papers and had some half a dozen further papers ready for publication. Indicative of the high regard in which the work of the Division of Metrology is held is the recent appointment[1] of its chief, Mr. N. A. Esserman, as the first director of the National Standards Laboratory. This is stated to be one of the first consequences of the recommendations made by a committee of the Advisory Council which reported last year on the future development of the Laboratory. Mr. Esserman remains directly responsible for the work of the Division.

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[1] *Nature*, 182, 291 (1958).

BRISTOL CITY MUSEUM

THE report of the City of Bristol Museum for 1957* continues the series of readable, well-produced and attractively illustrated publications issued annually by that Museum, in which it also continues to record a commendable extension of activities and responsibilities, evidenced by the introductory matter on the personnel and scope of committees and sub-committees on general museum work, on staffing and policy, on the preservation of ancient Bristol and on the Museum School Service. The latter, for years an informal advisory committee, has now become fully official, reflecting the increased volume of, and value placed upon, the work the Museum does for the schools of the area. It is presided over by the chairman of the City Museum and Art Gallery Committee, and its members include teachers serving in Bristol schools and representatives of departments of education.

Staff matters reflect the health of any museum. In this report, loyalty and long service to a respected institution are reflected in the retirement of the administrative assistant after forty-five years service —thirty-three years of which were with the Museum and Art Gallery—and of the museum foreman after twenty-two years. One member of the staff has obtained an M.A. degree and another the diploma of the Museums Association, while a third has left to take up a curatorial post in another institution. The director and staff also figure as officers or members of a variety of learned societies and advisory bodies, both national and local, and the list of research work accomplished and papers published is clear evidence of a busy institution.

The acquisition of Chatterton House, the birthplace of the boy-poet Thomas Chatterton, thanks to the generous intervention of the Dulverton Trust, adds to the many attractions Bristol Museum can offer. Temporary exhibitions continue to be a major offering to townspeople and visitors—a post-war feature of museums' activities, which take much time and give much trouble, but which are greatly worthwhile. The lenders range from the city librarian and city archivist to the Victoria and Albert Museum in London. Publications produced include a "Guide to Roman Buildings in Kings Weston Park" and leaflets on the Folk Museum at Blaise Castle House, as well as programmes of a highly successful series of winter lectures and summer conducted walks to places of historical or scientific interest in the neighbourhood. The services rendered are varied—from providing an attractive venue for official receptions given by the Lord Mayor, the Sheriff and the Vice-chancellor of the University of Bristol to housing a training course for students for the diploma of the Museums Association.

Departmental reports record valuable work on the coin collections, greatly used for reference purposes, new exhibits on African ethnology, primitive shipping, berries and twigs, British Lepidoptera for beginners and metalliferous mining in the Mendip Hills, and a new room devoted to Georgian costume as a contrast to the already popular Victorian room. The new Department of Conservation is proving its great worth and has a lengthy and interesting list of repairs completed, treatments accomplished, models made and exhibits prepared to its credit. Its organization has been greatly helped by the Works Laboratory of the Bristol Aeroplane Company—an interesting example of co-operation. Special reference is due to the work for schools, for which an additional assistant organizer has been appointed. Lessons in history, biology, geology and geography are given to an ever-increasing number of classes, and it is gratifying to note that children from nearly one-third of all the junior and secondary schools in Bristol attend, while the School Loan Services, with a better collection than ever before of specimens, models and photographs, are used by more than 70 per cent of the schools in the Bristol area. Teachers in training in seven institutions visit the Museum to learn how best to use museum facilities in their future professional practice. At the other end of the scale, the Saturday Club continues to enjoy an enthusiastic membership of young naturalists aged 9–11 years.

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* The City Museum, Bristol. Report of Committee for the year ended 31 December, 1957. Pp. 23. (Bristol: The City Museum, 1958.)

D. A. ALLAN

SOME PROBLEMS OF SMALL FIRMS

A SHORT report published by the Department of Scientific and Industrial Research gives details of one of the most encouraging services to industry carried out under its auspices*. It is a commonplace that the economic prosperity of Great Britain would be secure if a fair proportion of the many small firms and medium-sized firms could be brought up to a standard of efficiency equal to that of some of the bigger firms. One of the difficulties is that, hitherto, there has been an unbridged gap between research institutions with their store of valuable knowledge and the small and medium-sized firms who might well use this knowledge but lack trained scientists and technologists to guide them to it. This report describes the work of a technical liaison service which was organized in 1955–56 by the Scottish Council (Development and Industry), the broad purpose of which is to promote the economic development and well-being of Scotland. A team of three investigators, all men who had retired from responsible managerial or technical posts in industry, visited small and medium-sized engineering firms in the industrial belt of Central Scotland to find out what problems confront the smaller firms in the drive for greater efficiency and expansion; what equipment they possess for solving these problems for themselves; where to get help; and in what ways external sources could help.

During the survey the technical liaison service helped 109 firms, each with fewer than five hundred employees and with no elaborate management organization, to find solutions to 223 problems which they could not overcome with their own resources. Every interested firm was visited by a member of the team who helped to define each problem precisely and then to find a solution. Some questions could be answered on the spot from the member's own experience; the rest were referred to the Scottish Council's office in Edinburgh, where the technical co-ordinator of the project got in touch with the most likely sources of information.

The work of the experimental technical liaison service disclosed that:

(1) Firms in the survey were relying predominantly on trade contracts and other firms for information on new developments and techniques, and were accordingly in danger of operating within a closed circle.

(2) A few firms had ample technical resources, but most had few or none.

(3) Although many of the firms seemed to be attempting creative adjustments to new circumstances, only ten of them were managing to do so without introducing violent and disruptive changes. There were many reasons for this, but a predominant one was lack of technical information on which long-term plans could be based.

(4) Most firms were having difficulty in answering, from their own resources, some of the problems which affected their future plans; they discussed these with the technical liaison service.

(5) Half the problems had been previously abandoned, or were defined for the first time during discussions with the team, or with the staff of research and other organizations introduced by them.

(6) Answers to more than 70 per cent of the problems were found by the technical liaison service during the survey. The information required was in existence, but its sources unknown to, or unused by, the firms.

The outstanding success of the technical liaison service led the steering committee of the Scottish Council to recommend that a permanent technical liaison service should be provided; at first it would help small and medium-sized engineering firms, as the experimental service had done, but later it should be extended to other industries. The Committee indicated that the operation of regional schemes on these lines should be in the charge of the Department of Scientific and Industrial Research and suggested that the Secretary of State for Scotland should be asked if an official service could be provided. Meanwhile, the Committee felt that the service was so urgently needed that it should be run by a private Scottish institution until an official scheme could be established—preferably by an independent organization, like the Royal College of Science and Technology at Glasgow, since the experimental service gained much from the support of technical colleges and from easy access to technically qualified staff with industrial training.

The Scottish Education Department has recently authorized the expenditure required to set up a technical information service, on the lines proposed by the Scottish Council's steering committee, under the Department of Industrial Administration at the Royal College of Science and Technology, Glasgow. This extension of the Department's work is largely experimental and will be revised in not more than three years.

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* Small Firms with Big Problems: a Short Account of an Experimental Technical Liaison Service run by the Scottish Council (Development and Industry). Pp. iii+24. (London: Department of Scientific and Industrial Research, 1958.)

CONTRIBUTION OF HIGH-ENERGY PARTICLES TO THERMONUCLEAR REACTION RATES

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AND

Dr. H. MOTZ
Engineering Laboratory, University of Oxford

IN the course of work on a general study of the feasibility of thermonuclear power generation, we have examined the reactions :

$${}^2_1\mathrm{D} + {}^2_1\mathrm{D} \rightarrow {}^3_2\mathrm{H} + {}^1_0n\,(3\cdot265 \pm 0\cdot018)\,\mathrm{MeV.}\ \text{(ref. 1)} \quad (1)$$

$${}^2_1\mathrm{D} + {}^2_1\mathrm{D} \rightarrow {}^3_1\mathrm{T} + {}^1_1p\,(0\cdot0136 \pm 0\cdot022)\,\mathrm{MeV.}\ \text{(ref. 1)} \quad (2)$$

$${}^3_1\mathrm{T} + {}^2_1\mathrm{D} \rightarrow {}^4_2\mathrm{He} + {}^1_0n\,(17\cdot577 \pm 0\cdot02)\,\mathrm{MeV.} \quad (3)$$

In view of the recent experimental results obtained by means of ZETA at Harwell[2] it seemed to us worth while to communicate some of our results concerning thermonuclear reaction-rates. These results show in detail the contribution of particles of various energy groups to the total reaction-rates. It will be seen that in all cases considered the main contribution comes from a rather small number of particles with energy much higher than the mean thermal energy of the particles.

Attention was directed to this fact by Post[3], who points out that "the tail of the Maxwell distribution wags the dog". These results point to the possibility of using acceleration processes within a gas discharge for the purpose of production of fusion power. The Harwell results quoted above indicate that the neutron yield of ZETA is in fact due to non-equilibrium processes.

The reaction-rate in a hot plasma with nuclei of type A and of velocity $u = (u_1, u_2, u_3)$ and type B of velocity $v = (v_1, v_2, v_3)$ is given by :

$$R_{AB} = \int_{-\infty}^{\infty} f(u_1)\mathrm{d}u_1 \int_{-\infty}^{\infty} f(u_2)\mathrm{d}u_2 \int_{-\infty}^{\infty} f(u_3)\mathrm{d}u_3 \int_{-\infty}^{\infty} g(v_1)\mathrm{d}v_1 \int_{-\infty}^{\infty} g(v_2)\mathrm{d}v_2 \int_{-\infty}^{\infty} g(v_3)\mathrm{d}v_3 . \sigma(w) \quad (4)$$

where f and g are velocity distribution functions such that the particle numbers in a volume element of velocity space are given by :

$$\mathrm{d}n_A = f(u_1)\, f(u_2)\, f(u_3)\, \mathrm{d}u_1\, \mathrm{d}u_2\, \mathrm{d}u_3$$
$$\mathrm{d}n_B = g(v_1)\, g(v_2)\, g(v_3)\, \mathrm{d}v_1\, \mathrm{d}v_2\, \mathrm{d}v_3$$

and w is the absolute value of the relative velocity :

$$w = |\vec{u} - \vec{v}| \quad (5)$$

while $\sigma(w)$ is the cross-section of the reaction between A and B. When the velocity distribution is Maxwellian, it is easy to show from (4) that in a system where the nuclei B are at rest and the nuclei A have velocity w and kinetic energy $E = m_A w^2/2$:

$$R_{AB} = (8\pi n_A n_B/m^2_A)\,(m/2\pi kT)^{3/2} \int_0^{\infty} E\sigma_{AB}(E) \exp\,(-\,mE/m_A kT)\mathrm{d}E \quad (6)$$

where m is the reduced mass :

$$m_A \,.\, m_B \,/\, (m_A + m_B)$$

and $\sigma_{AB}(E)$ is the cross-section of the reaction between A and B.

Gamov and Teller[4] have shown that the cross-section for penetration of a Coulomb barrier of height $Z_A Z_B e^2/r_0$ between nuclei of atomic numbers Z_A and Z_B and masses m_A and m_B is given by :

$$\sigma_{AB} = A/E \exp(-\,B\,E^{-1/2}) \quad (7)$$

where

$$A = (m_A \pi \hbar^2/2m^2) \exp\,(4/\hbar)\,(2m\,Z_A Z_B e^2 r_0)^{1/2}$$
$$B = \pi Z_A Z_B\,\alpha_f (2m_A c^2)^{1/2}$$

and α_f is the fine-structure constant.

At low energy the fusion cross-section is of the form :

$$\ln E\sigma_{AB} = A' - E^{-1/2}B' \quad (8)$$

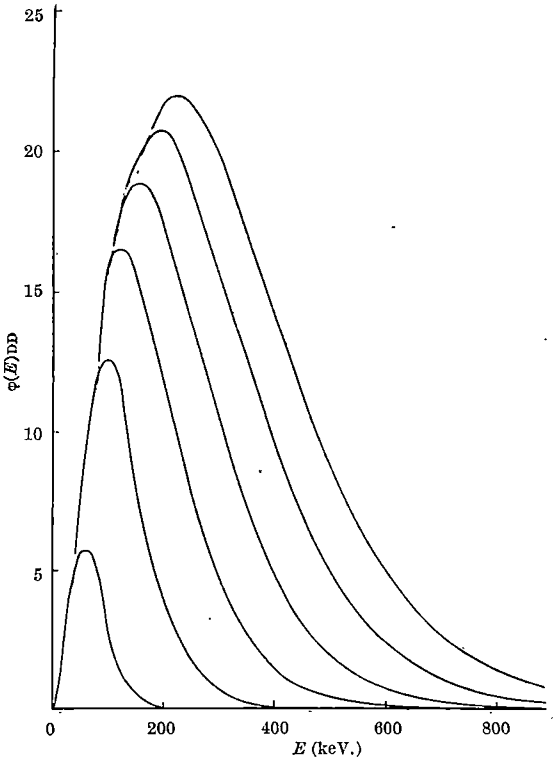

Fig. 1. Contribution to the reaction rate R_{DD} as a function of the deuteron energy E for kT = (left to right) 10, 20, 30, 40, 50, 60 keV.

We have determined the constants A' and B' from the experimental data for reactions (1), (2) and (3) as determined by Arnold and co-workers[5].

At higher deuteron energies for reaction (3) the experimental results of Argo and co-workers[6] were used. These experiments were carried out with triton beams of energy E_T in the laboratory system. Transforming to the system where the tritons are at rest the corresponding deuteron energies are given by:

$$E_D = (m_D/m_T)E_T = 0{\cdot}6677\ E_T$$

The cross-sections for reaction (2) have been measured by Wenzel and Whaling[7]. The total cross-section for reactions (1) and (2) has been determined by McNeill and Keyser[8] and the ratio of the cross-sections (1) and (2) has been determined by McNeill, Thoneman and Price[9]. Low energy measurements for reaction (2) by Moffat, Roaf and Sanders[10,11] are also available. We have computed the total reaction rate $R_{DD} = R_1 + R_2$ and $R_{DT} = R_3$, where the suffixes refer to the processes listed above. Formula (6) was used, which becomes:

$$R_2 = (n_\mathrm{D}\mathrm{cm.}^3)^2\ 10^{-21}\ \mathrm{cm.}^{-3}\ \mathrm{sec.}^{-1}\int_0^\infty \varphi_2(E)\ \mathrm{d}\ (E/\mathrm{keV.}) \quad (9)$$

where

$$\varphi_2(E) = 8{\cdot}733\ (kT/\mathrm{keV.})^{-3/2}\ \exp(-E/2kT)\ (\sigma_2(E)E/\mathrm{millibarn/keV.})$$

for reaction 2, and for reaction 3

$$R_3 = (n_\mathrm{D}n_\mathrm{T}\ \mathrm{cm.}^6)\ 10^{-17}\ \mathrm{cm.}^{-3}\ \mathrm{sec.}^{-1}\int_0^\infty \varphi_\mathrm{DT}(E)\ \mathrm{d}\ (E/\mathrm{keV.}) \quad (10)$$

with

$$\varphi(E)_\mathrm{DT} = 1{\cdot}622(kT/\mathrm{keV.})^{-\ /2}\ \exp\ (-\ 0{\cdot}5996\ E/kT)\ (\sigma_3(E)E/\mathrm{barn/keV.})$$

where all quantities are expressed in terms of the units indicated.

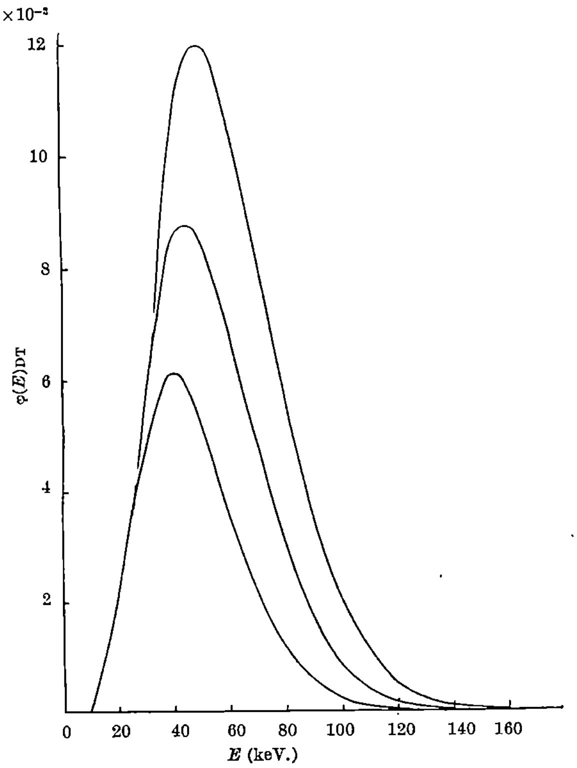

Fig. 2. Contribution to the reaction-rate R_{DT} as a function of the deuteron energy E for kT = (left to right) 6, 7, 8 keV.

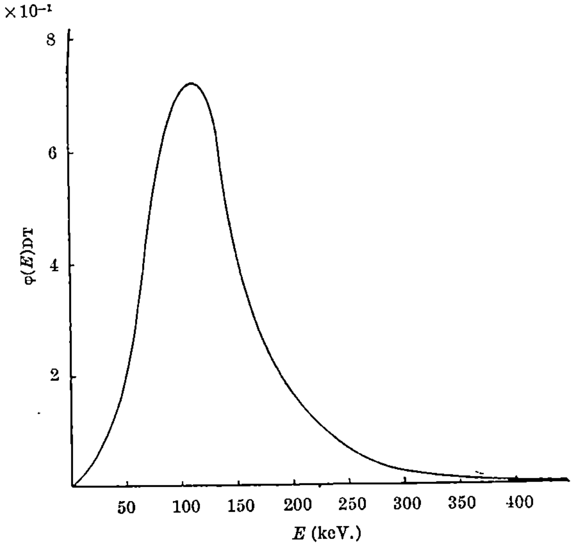

Fig. 3. φ_DT as a function of E for kT = 40 keV.

Fig. 1 shows φ_DD for temperatures of 10–60 keV. in steps of 10 keV. Fig. 2 shows φ_DT for temperatures of 6, 7 and 8 keV. Fig. 3 shows φ_DT for a temperature of 40 keV. It is seen that the reaction-rate is in each case mainly due to particles belonging to the tail of the Maxwell distribution. The total reaction-rates were computed in accordance with formulæ (9), (10) by integration over dE.

An approximation to the reaction-rate can be obtained by means of a method due to Gamov. One can write, in first approximation:

$$\int_0^\infty \varphi(E)\mathrm{d}E = \Delta E\varphi(E_m) \quad (11)$$

because the integrand is of the form

$$\varphi(E) = \exp\{-\ (mE/m_AkT) - B'E^{-1/2}\} \quad (12)$$

and has a sharp maximum as a function of E at $E = E_m = (B'm_AkT/2m)^{3/2}$. If ΔE is defined by:

$$\varphi(E + \Delta E/2) = \varphi(E_m)/e \quad (13)$$

ΔE is given by:

$$\Delta E = (32/3\ B')^{1/2}\ (B'm_AkT/2m)^{5/6} \quad (14)$$

In the results for the DD and DT reaction-rates which have been tabulated below, the values for E_m, the energy of the maximum contribution to the reaction-

Table 1. R_DD IN UNITS OF 10^{-16} CM.$^{-3}$SEC.$^{-1}$ $(n_\mathrm{D}\mathrm{cm.}^3)^2$

kT	E_m (Gamov)	E_m	R_DD (Gamov)	R_DD	Per cent effective
10 keV.	59 keV.	59 keV.	0·60	0·98	11
20	94	104	2·38	3·40	16
30	124	124	4·45	6·75	24
40	150	134	6·46	10·11	34·2
50	174	185	8·33	13·87	29·6
60	196	225	10·03	17·96	29·7

Table 2. R_DT IN UNITS OF 10^{-18} $(n_\mathrm{D}n_\mathrm{T}\ \mathrm{cm.}^6)$ CM.$^{-3}$ SEC.$^{-1}$

kT	E_m	R_DT	Per cent effective
2 keV.	19·8 keV.	0·263	0·71
4	31·6	5·91	2·3
6	40·6	25·71	4·27
7	44·4	40·27	5·4
8	48	60·51	6·52
40	110	748	25

rate, have been entered, together with the computed reaction-rates for various temperatures.

In Table 1 for the D–D reaction we have included the values of E_m and R_{DD} as computed from the Gamov approximation. It is seen that the Gamov approximation holds only for low temperatures.

It is interesting to compute the mean energy $m_D\overline{u^2}/2$ of deuterons in the laboratory frame of reference which have relative energy $E = m_D W^2/2$ on collision. Statistical analysis gives the result :

$$m_A\overline{u^2}/2 = \tfrac{1}{2}m_A\, W^2\, (m/m_A)^2 + 3/2\, kT\, (m/m_B) \qquad (15)$$

where m is the reduced mass.

Conversely, one can compute the mean relative energy on collision of deuterons with energy $m_D u^2/2$ in the laboratory system. The result is :

$$m_A\, \overline{W^2}/2 = m_A u^2/2 + 3/2\, kT\, (m_A/m_B) \qquad (16)$$

Using these results Tables 3 and 4 can be computed for D–D and D–T reactions :

Table 3. D–D REACTIONS

kT (keV.)	10	20	30	40	50	60
E_m (keV.)	59	94	124	150	174	196
$m_D\overline{u^2}/2$ (keV.)	22	39	54	68	81	94
$m_D u^2/2$ (keV.)	44	64	79	90	99	106

Table 4. D–T REACTIONS

kT (keV.)	2	4	6	7	8	40
E_m (keV.)	19·8	31·6	40·6	44·4	48·0	110
$m_D\overline{u^2}/2$ (keV.)	8·35	14·1	18·2	20·2	22·1	63·8
$m_D u^2/2$ (keV.)	17·8	27·6	34·6	37·4	40	70

The energies $m_D u^2/2$ have been computed from equation (16), where $m_A\overline{W^2}/2$ has been identified with E_m. They are thus the energies of deuterons which have a mean relative energy equal to the relative energy giving the maximum contribution to the reaction rate.

In Tables 1 and 2 there are columns headed 'per cent effective'. These are the percentages $\Delta n_A/n_A\,.100$ of deuterons with relative energy larger than E_m computed from :

$$\Delta n_A/n_A = n_B\, 4/\sqrt{\pi}\int_z^{\infty} z^2 \exp(-z^2)\, dz$$

where the lower limit of the integral is given by $Z = (mW^2/2)^{1/2}$ and m is again the reduced mass.

Looking at these tables one notes that ions with fairly low energies in the laboratory system have on average a high relative energy. This may be relevant when one is considering the effect on the reaction-rate of accelerated deuterons inserted into a discharge. Looking at Table 2 one notes that in the case of the D–T reaction the effective percentages are rather low, again showing that relatively few accelerated deuterons injected into a plasma may produce reaction-rates comparable to the purely thermonuclear ones. A complete discussion of these effects would, of course, have to include acceleration processes and energy loss of extra particles. Such studies are being undertaken at Oxford.

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PERMANENT MOISTURE EXPANSION OF CLAY PRODUCTS ON AUTOCLAVING

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IN the course of a study of the permanent moisture expansion of clay products we have found that all such products so far examined expand once they leave the kiln and are exposed to the action of water or water vapour. We have also found that reproducible maximum or total expansions, usually many times greater than expansions so far reported, are obtained by autoclaving the kiln-fresh samples in saturated steam at elevated temperatures until stable dimensions have been attained, the actual temperature of autoclaving being unimportant. About 400 industrial and laboratory specimens have now been autoclaved for 24-hr. periods at 200° C. (225 lb./sq. in. absolute) until expansion ceased, and the average and range of the total moisture expansions (measured after drying for 48 hr. at 110° C.) for eight types of product are given in Table 1; curves for the average expansion with time for each of these products are given in Fig. 1, and the curves for two individual bricks, one light-burnt the other hard-burnt from the same kiln sampling, in Fig. 2. Because of the small numbers of some of the products examined so far, the values presented cannot be considered as completely characteristic, but they do indicate the general trends for the various bodies.

With values now available for maximum or total expansion, more reliable conclusions than have been possible in the past on the basis of incomplete

Table 1. PERMANENT MOISTURE EXPANSION FOR EIGHT TYPES OF CLAY PRODUCTS

Product	No. examined	Expansion	
		Average (per cent)	Range (per cent)
Floor tile	12	0·50	0·60–0·32
China body	6	0·39	0·44–0·34
Brick	220	0·35	0·85–0·16
Firebrick	6	0·28	0·29–0·26
Refractory body	6	0·27	0·28–0·26
Roofing tile	89	0·25	0·42–0·13
Wall tile	10	0·19	0·23–0·17
Architectural terra-cotta	6	0·16	0·17–0·14

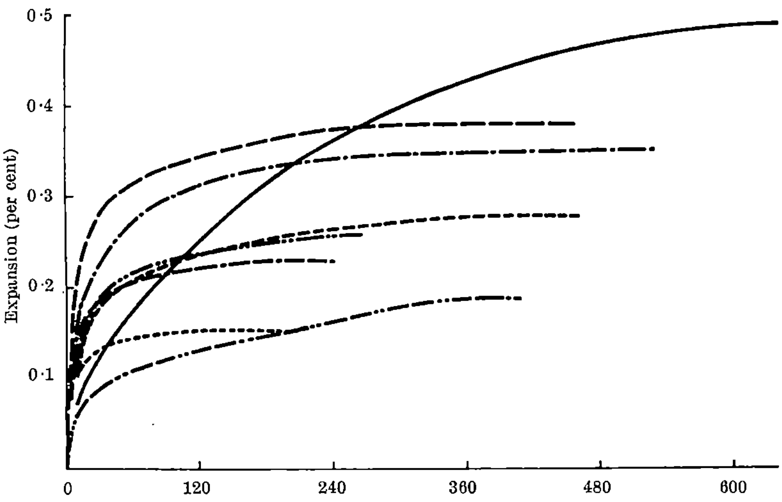

Fig. 1. Average permanent moisture expansion for eight types of clay product. · · · ·, Architectural terra-cotta; · – – – · ·, wall tile; ——, floor tile; – – –, china body; – · – ·, brick; - - -·, firebrick; · · – · ·, refractory body; · – – –·, roofing tile

expansions may be drawn as to the influence of such factors as the temperature of the moisture to which they are exposed, raw materials or body composition, methods of manufacture and firing temperature on the rate and extent of the expansion of various bodies.

That the rate of expansion of ceramic bodies varies with the temperature of the moisture to which they are exposed has been observed by many workers[1–6]. This has not only been confirmed by the present work, but by recalculating our figures and those of Mattyasovszky-Zsolnay[3], Bullin and Green[4] and Smith[5] to the hours of treatment necessary to give the same expansions in one hour at 200° C., we have been able to show that the temperature coefficient of the rate of expansion, at least in the early stages, is similar for a wide range of bodies and temperatures of reaction. For ceramic bodies generally the average rate of expansion is shown to change approximately 1·8 times for each 10 deg. C. variation in temperature, a figure which may be compared with the usual value of about 2 for the temperature coefficient of chemical reaction.

The above workers believed that the extent of expansion was also affected by the temperature of the moisture, but since none of their measurements was continued until dimensional stability of the body was reached, it is now clear that what appeared to be an increased expansion is merely another expression of increased rate.

In studying the effects of body composition and temperature of firing on expansion, certain workers[1,2,7] concluded that for a given body composition the moisture expansion decreased as the firing temperature increased. Holscher[1] and Thiemecke[2] considered further that vitrified bodies did not expand at all. Bullin and Green[4] and Norris[8], however, showed that apparent reductions in expansion with increased firing temperatures were due to reductions in rate rather than in extent, and their conclusions are more in accord with our results. These show that while all bodies examined, including well-vitrified ones, expanded on contact with moisture, the relationships between expansion and firing temperature are most complex and cannot be expressed in general terms. The relationships vary according to the composition and structure of the different bodies, and for any particular body they depend on the stage in the progress of the expansion at which they are compared (Fig. 2). For some bodies the total expansion increases as the temperature increases up to the maximum of practical firing, in which case well-vitrified and bloated samples expand most of all. In some cases the relationships are reversed, in others the maximum expansions occur at an intermediate temperature, and for some bodies there is little difference in the amount of expansion throughout the whole firing range. In general, the rate of expansions of the light-burnt products is much faster in the early stages of reaction than that of the harder-burnt products, and the lighter-burnt products reach their total expansion in a shorter time.

A study of the expansion curves for many well-burnt products shows that the relationships between expansion and time may be expressed by the equation:

$$E_t = E_T\,(1 - e^{-kt})$$

in which E_t per cent is the expansion at any time t hours, E_T per cent is the total expansion, and k is a constant. Such an equation is similar to that for a first-order chemical reaction in which E_T is a function of the concentration of the components which on hydration give rise to expansion, E_t depends on the amount of material hydrated in time t, and k is the velocity constant. Hence, the reactions responsible for expansion obey first-order kinetics. For the hard-burnt brick the expansion of which is illustrated in Fig. 2, the derived equation, in which t

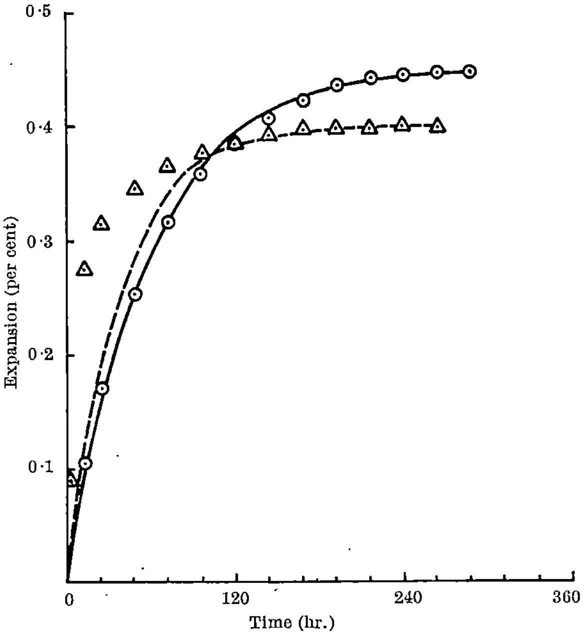

Fig. 2. Experimental and derived permanent moisture expansion for a light-burnt and a hard-burnt brick from the one kiln sampling. Hard-burnt: ⊙, experimental; ——, derived values. Light-burnt: △, experimental; – – –, derived values

is expressed in hours of autoclaving and 0·450 per cent is the total expansion, is :

$$E = 0{\cdot}450\ (1 - e^{-0{\cdot}018t})$$

and the good fit between the derived and experimental values is apparent.

When the similar equation :

$$E = 0{\cdot}403\ (1 - e^{0{\cdot}026t})$$

is applied for the light-burnt product and the experimental and calculated values are compared (Fig. 2), it is seen that although there is good agreement in the later stages of the reaction, expansion in the early stages is much faster than would be the case if the curve followed a simple first-order reaction as closely as does that of the well-burnt brick. It is considered that this difference in the behaviour of the two bricks is due to differences in the structures of the reactive compounds produced at the two temperatures. In the well-burnt body the reactive compounds are probably glassy, whereas in the light-burnt one they are probably non-vitreous amorphous silicates and dehydrated clay minerals with a much more open structure and larger surface-area ; hence the water is able to diffuse into the reactive compounds of the light-burnt body more rapidly, and expansion in the initial stages is at a higher rate than that in the hard-burnt body. Smaller differences between predicted and experimental values are found in bricks from the same sampling burnt at intermediate temperatures, and in which a change-over from non-vitreous to vitreous compounds undoubtedly occurs.

These investigations are proceeding, and full progress accounts are in course of preparation.

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ANTI-TUMOUR AND BIOCHEMICAL EFFECTS OF PURIFIED BOVINE XANTHINE OXIDASE IN *C3H* AND *C* MICE

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THE observation[1] that xanthine oxidase inhibits the growth of spontaneous mammary carcinoma in mice carrying the Bittner factor was discussed at a Ciba Foundation Symposium[2] in relation to the lower levels of the activity of this enzyme in the tumour cell when compared with the normal cells from breast tissue of low-tumour strain (*C* –) and high-tumour strain (*C* +) mice, as established by Lewin *et al.*[3].

It then became clear that further work ought to deal in an extended manner with the confirmation of the preliminary results and with the problem of the fate of injected xanthine oxidase in the animal organism. The second point required special attention as the xanthine oxidase concentrate used for the early chemotherapeutic experiments was of bovine origin, having a molecular weight of about 300,000. Criticism of the connexion between anti-tumour effects and enzyme properties could be based on the possibility that the 'foreign' protein might exert a non-specific action and that the large molecule might not be taken up by the mouse tissue or cells. In the following we wish to report on the outcome of recent investigations in both directions.

Chemotherapeutic experiments. The first trial run of the new series attempted a comparison between the effects on mammary tumours of *C3H* and *C* + mice of a xanthine oxidase concentrate from cow's milk[4] with a preparation which had lost most of its enzyme activity through storage but differed chemically and physico-chemically very little from the material with full catalytic activity[5]. Both concentrates ('active' : *AFR* = 90 ; 'inactive' : *AFR* = 6) were injected intraperitoneally twice daily using 10 mgm. doses of xanthine oxidase in 1 ml. saline, together with 0·2 mgm. of sodium salicylate. (Specific activities are expressed as *AFR* values[4] ; all the samples used in this and subsequent experiments had E_{280}/E_{450} (that is, *PFR*) values of about 7–8 ; weights of xanthine oxidase are calculated from E_{450} values[5].) Sodium salicylate had been found to stabilize the active enzyme considerably[6]. Perhaps because of the presence of salicylate, which is also an inhibitor of xanthine oxidase, the growth-rates of the tumours (measured in two perpendicular directions and expressed as surface area) were not slowed down very distinctly, though the impression was gained that in the mice treated with the active enzyme preparation the over-all effect was somewhat larger.

The next trial was carried out with active concentrates which were prepared following a differensequence of purification steps than for previout batches. The procedure, in some respects similar to that of Klenow and Emberland[7], consisted of treatment with butanol, ammonium sulphate fractions ation and calcium phosphate chromatography after enzymic digestion of buttermilk. In view of the above-mentioned difficulties the material containing salicylate was dialysed against sodium chloride and thus freed from the stabilizer-inhibitor a short time before use. The solutions had *AFR* values of 50–100, and 5 mgm. doses in 1 ml. of saline were injected daily intraperitoneally. A group of 18 tumour-bearing *C* + and *C3H* mice and an equally large control group which received saline injections were used. The results are graphically represented in Figs. 1*A* and *B*. Fig. 1*A* shows the mean relative tumour

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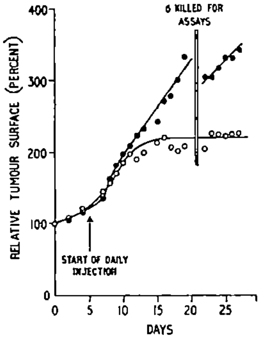

Fig. 1*A*. Experiment with eighteen *C3H* and *C*+ mice in each group. ●—●, Controls on saline injection; ○—○, animals treated with 5 mgm. xanthine oxidase daily. Relative tumour surface = (surface of tumours at each day × 100/surface of tumours at time zero)

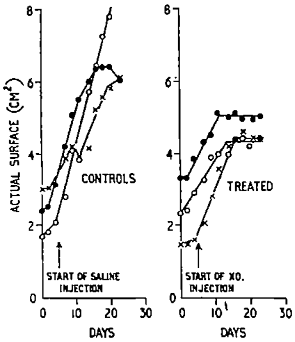

Fig. 1*B*. Actual tumour surface area of three representative individual animals from each group of Fig. 1*A*

surface for the respective groups, and Fig. 1*B* gives the actual surface values (cm.^{2}) of representative individual animals. Although the growth-rate of the tumours was variable a definite inhibitory action of the enzyme preparation could be observed. It is noteworthy that on cessation of the xanthine oxidase injections the tumours which had been arrested appeared to regain growth-rates similar to those of the controls, results which are not given in Figs. 1*A* or *B*.

Biochemical experiments. It was pointed out at the beginning that it was important to establish beyond doubt the accumulation of the extraneously introduced enzyme in measurable amounts in the organs of the mice. For this purpose the fate of injected milk xanthine oxidase was followed by quantitative assay in three ways. The levels of activity were estimated[3] in the intraperitoneal cavity and in the liver of *C* – mice after intraperitoneal injection of xanthine oxidase. An 'inactive' enzyme concentrate, bovine plasma albumin (Armour), 'supernatant' solutions from thermal denaturation of the enzyme and albumin and supernatant together were also studied. (The 'inactive' sample was prepared from a portion of the active one by irradiating with a tungsten lamp for 13 hr. The solution was immersed in a bath at 37° C. and stirred gently in an open vessel during irradiation. Water was added to make good the evaporation, and a slight precipitate was centrifuged off. The 'supernatant' solution was prepared by immersing a portion of the active enzyme solution in a boiling water-bath for 5 min. with protection from light and then decanting the clear solution.) Finally, the xanthine oxidase activity was measured in the tumour tissue and livers of treated and control *C3H* and *C* + animals.

Table 1. EFFECT OF INJECTIONS ON LEVELS OF XANTHINE OXIDASE ACTIVITY IN PERITONEAL CAVITY AND IN LIVER. ENZYME ACTIVITY:

Time after injection (hr.)	Intraperitoneal cavity			Liver		
	Intraperitoneal washings: 10³ units (ref. 4)		Per cent of injected dose	Total liver homogenate: 10³ units (ref. 4)		Per cent of injected dose
	Controls	Treated		Controls	Treated	
4	0	1·76	1·4	2·05	7·68	6·1
6	0	1·24	1·0	2·28	7·77	6·2
24	0	0·05	0·04	2·31	7·62	6·0

The treated *C* – mice received 5 mgm. (0·126 unit, ref. 4) of xanthine oxidase intraperitoneally. At the time of death, 2 ml. of 0·15 *M* sodium chloride were injected intraperitoneally to wash the cavity. The mice were massaged and then 1 ml. of the injected liquid was taken out. Determinations of xanthine oxidase were carried out on this liquid and on the excised livers. The controls were treated similarly with 0·15 *M* sodium chloride. All values are the mean of two determinations.

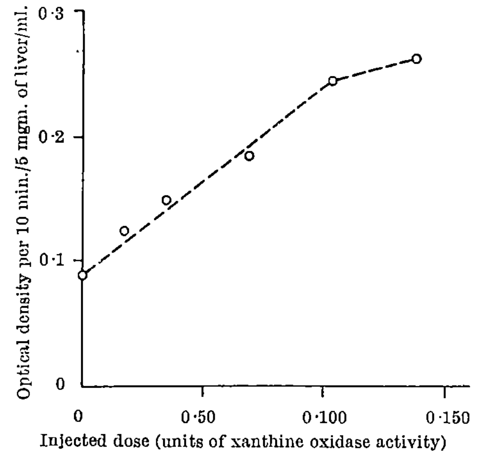

Fig. 2. Relation between liver xanthine oxidase activity and injected dose (in 2 ml. saline) 4 hr. after injection. The first point is the mean of determination on twelve *C* – mouse livers and the others of two. The livers were thoroughly washed in pyrophosphate buffer before homogenization

As can be seen from Table 1, washings of the intraperitoneal cavity still contained a measurable amount of the injected xanthine oxidase after four hours, this quantity falling to zero after 24 hours. An assay of the liver of the same animals indicated a substantial rise in the level of enzyme activity over the controls. It was then decided to test different amounts of xanthine oxidase to see whether the increase in the liver depended on the quantity of enzyme injected. As Fig. 2 shows clearly, the increase of xanthine oxidase activity in the liver is practically proportional to the dose up to about 0·1 unit, at which value the curve begins to level off. In another experiment the effects of the enzyme were compared with those of various other injections as mentioned before (Fig. 3). Active xanthine oxidase

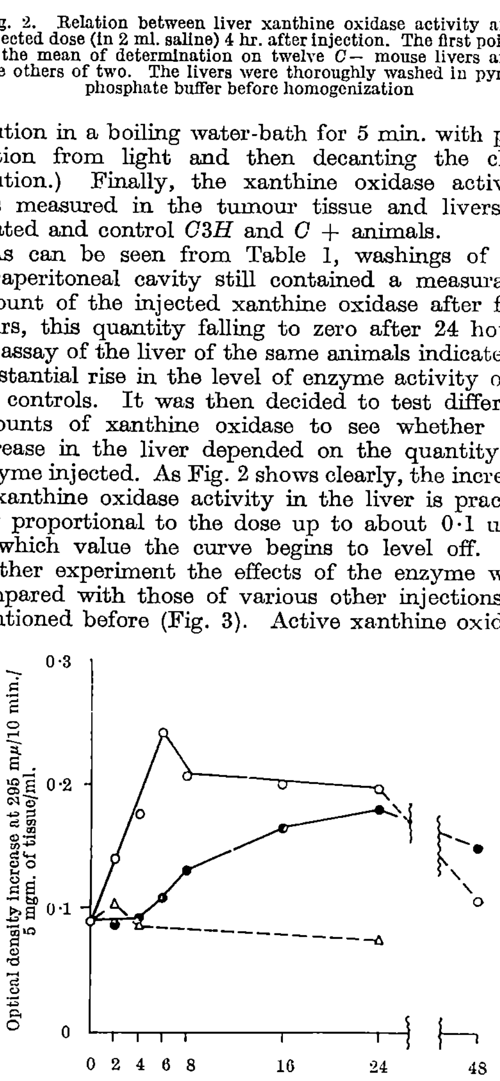

Fig. 3. Effect of injections on liver xanthine oxidase activity. Active xanthine oxidase: *AFR* = 95; 5 mgm. in 1 ml. saline. 'Inactive' concentrate *AFR* = 4; 5 mgm. in 1 ml. saline. Supernatant from equivalent of 5 mgm. enzyme. Crystallized bovine plasma albumin (Armour) 10 mgm. in 1 ml. saline or in 1 ml. of supernatant. The first point is the mean of determinations of twelve *C* – mouse livers and the others of three. The livers were thoroughly washed in pyrophosphate buffer before homogenization. ○—○, Active xanthine oxidase; ●—●, 'Inactive' xanthine oxidase; ◁—△, albumin, supernatant or both

Table 2. EFFECTS OF XANTHINE OXIDASE INJECTIONS ON TUMOUR-BEARING ANIMALS

	No. of animals	Mean xanthine oxidase activity 10^5 μmoles/min./mgm.	
		Tumour	Liver
Treated	4	24·4	40·0
Controls	6	10·0	14·3

Some tumour-bearing mice, from Fig. 1*A*, were killed after fifteen daily injections of xanthine oxidase or saline. The tumour tissue and the livers were used for xanthine oxidase assays; the activity is expressed in terms of uric acid formed per mgm. of fresh tissue.

increased the liver activity to 2·75 times that of the normal liver, 6 hours after injection, whereas bovine albumin and the supernatant were without effect. On the other hand, 'inactive' enzyme gave an increase to twice the normal level, the maximum effect occurring later than with the active preparation, namely, about 24 hours after the injection. This time-lag suggests that the inactive material is reactivated in the tissues of the mice.

Finally, Table 2 shows that in treated *C3H* and *C* + animals bearing tumours, not only the livers but also the tumour itself shows a higher xanthine oxidase activity-level than in the controls.

Conclusions and further outlook. From the results, just reported, it can be concluded that xanthine oxidase, even from a different species, can hold up the growth of spontaneous mammary tumours in *C3H* and *C* + mice. This is accompanied by an increase of the activity levels of xanthine oxidase in the livers and tumours of the treated animals. In experiments with *C* − animals it could also be demonstrated that the bovine enzyme causes an increase of the xanthine oxidase of liver, the levels being dependent on the amounts injected. 'Inactive' enzyme preparation was apparently reactivated in the liver but gave less rise than the concentrate with full enzymic activity. On the other hand, neither the 'supernatant' fraction nor bovine albumin or a combination of both produced any effects. While all this suggests strongly that the active xanthine oxidase molecules penetrate into the liver and tumour of the animals, and explains to some extent the observed changes in growth-rates of the tumours, it does not explain the underlying mechanism. It could be a case of replacement therapy, the injected xanthine oxidase making good the apparent deficiency in the tumour tissue. Whether this leads to an increase in purine catabolism, or a removal of growth-promoting pteridines or is simply an effect of increased intracellular hydrogen peroxide production, can only be decided after further work has been carried out. Tests on other tumours deficient in xanthine oxidase, such as the Novikoff hepatoma[8], assays of excretion of xanthine metabolites in urine, estimation of pteridines, studies of the effect of short[9] and long-term[2] application of xanthine on endogenous xanthine oxidase, could help in finding out more about our results. Only then could one think of extending the chemotherapeutic investigation to include combinations of xanthine oxidase with other related enzymes or with drugs, and to attempt, after immunological and pharmacological tests, corresponding trials in human patients.

We acknowledge the considerable help given by Mr. C. Smith in handling the animals and the technical assistance by Messrs. P. Trumper, A. Green, B. Mansfield and Miss A. M. Scott. The work has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

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GAS CHROMATOGRAPHIC TERMS AND DEFINITIONS

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IN several discussions I have had with workers in the field of gas chromatography, it appeared that much clarification remains to be achieved in nomenclature and definitions of terms, and that two causes of confusion stand out. The first is the ambiguous meaning of height equivalent to a theoretical plate (HETP); the second is the impossibility of drawing precise conclusions about the resolution (or resolving power) of a chromatographic column from a knowledge of the number of theoretical plates of that column, regardless of which of the two available definitions of the height equivalent to a theoretical plate is adopted. Both causes of confusion lose relevance when the retention-time of sample components, t, becomes very large when compared with the retention-time of inert gas packets, t_a, but the validity and usefulness of a system of terms and definitions should extend to those cases where t is no longer very large when compared to t_a.

The height equivalent to a theoretical plate has been defined[1] as that height of individual column portions which, if lumped into as many separate funnels of a Craig's machine, will cause the column so transformed to reproduce, in theory, the observable times t, t_a and Δt of the elution curves. When Δt designates the 'band-width at mid-height', the definition given leads to the following number of theoretical plates in a column[2]:

$$n_0 = 8 \ln 2 \frac{t(t - t_a)}{(\Delta t)^2} = 5{\cdot}54 \frac{t(t - t_a)}{(\Delta t)^2} \qquad (1)$$

The height equivalent to a theoretical plate has also been defined as that height of individual column portions which, if lumped into as many continuous absorption vessels[3], will cause the column so transformed to reproduce, in theory, the observable times of the elution curves. With this more usual definition, which will be the one adopted here, the number of theoretical plates is given by:

$$n = 5{\cdot}54 \, \frac{t^2}{(\Delta t)^2} \qquad (2)$$

The height equivalent to a theoretical plate thus defined can be connected in a simple manner with certain column characteristics. For example, if tu(cm.^{2}) designates the second moment, with respect to the column abscissa x, of a component distribution of total mass normalized to unity, the height equivalent to a theoretical plate (cm.) represents the increase of this second moment as the component packet travels 1 cm. in the column:

$$\text{HETP} = \frac{du}{dx} \qquad (3)$$

If the column consists of a capillary tube, uniformly coated with a retentive layer within which diffusion time is negligibly small, the following equation can be derived for the quantity above[4]:

$$\frac{du}{dx} = 2\frac{D}{v_0} + \frac{1 + 6k + 11k^2}{24(1+k)^2}\,\frac{v_0 r_0^2}{D} \qquad (4)$$

where D(cm.^{2} sec.$^{-1}$) is the rate of diffusion of component molecules in carrier gas; v_0 (cm. sec.$^{-1}$) is the average speed of carrier gas; and $k = (t - t_a)/t_a$ is the ratio of fixed phase capacity to moving phase capacity for the component; while r_0 (cm.) is the radius of the capillary.

It should be particularly noted that the very simple first term of the right-hand side of equation (4) represents the static diffusion term and corresponds to the second term of van Deemter's equation[5]. No other definition of the height equivalent to a theoretical plate can lead to a term in D/v_0 as simple as the one above, which should always be found (with a tortuosity factor γ for packed columns) in any theoretical expression purporting to connect the height equivalent to a theoretical plate with physical column parameters.

But the real measure of a column's efficiency is the resolution or resolving power of this column, that is, the potential ability of the column to separate two substances which differ but little in their affinity for the fixed (liquid or solid) phase. This resolution will be defined here as the inverse of the 'relative band-width', $\Delta t/(t - t_a)$:

$$R = \frac{t - t_a}{\Delta t} = \frac{k}{1+k}\,\frac{t}{\Delta t} \qquad (5)$$

When R is known for a given column and for one of a given pair of closely similar components, the 'relative separation', S_{12}, achievable for these components—the ratio of their actual time separation in the elution curve, Δt_{12}, over the band-width of one or the other, Δt_1 or Δt_2—will be immediately calculable from R and from the ratio of the partition coefficients, C_1 and C_2, of these components for the fixed phase, this ratio being a dimensionless physical quantity depending solely upon the nature of the two components and of the fixed phase, and not upon any design parameter of the column. Let ε designate the Naperian logarithm of the C_2/C_1 ratio. We have, with very good approximation:

$$S_{12} = \frac{2\Delta t_{12}}{\Delta t_1 + \Delta t_2} = R\,\frac{2(C_2 - C_1)}{C_2 + C_1} = R\varepsilon \qquad (6)$$

It is noted that the quantity of decisive interest, R, cannot be unambiguously derived from n (nor from n_0) as defined above. This is really as it should be, for a decision about the optimum k should be made, before R can be determined from the relation:

$$R = \frac{k}{1+k}\sqrt{\frac{n}{5{\cdot}54}} \qquad (7)$$

It is at this point that the performance index (P.I.) may be brought into play to help decide the optimum k, and thus to constitute the needed link, based on a physical theory, between fabricating parameters, such as the number of theoretical plates, and operating parameters, such as the resolution. The performance index was originally introduced[6] as a quantity which is nearly invariant in 'ideal' capillary columns (namely, columns in which the diffusion-time in the fixed phase is negligibly small), operated at the optimum flow-rate, and which could serve as a measure of the intrinsic goodness of a column. Since the publication of the original communication[6], a more rigorous theoretical treatment of capillary columns has been made, and this led to the slightly modified definition given below, in which the factor 15/16 has been substituted for the former factor 3/4 [7]:

$$\text{P.I.} = \frac{(\Delta t)^4\, t_a\, \Delta p}{t^3(t - 15t_a/16)} \qquad (8)$$

where Δp designates the drop in pressure across the column. When the performance index is written as follows:

$$\text{P.I.} = \left(\frac{\Delta t}{t - t_a}\right)^4 \cdot \frac{(t - t_a)^4\, t_a}{t^4\,(t - 15t_a/16)} \cdot t\Delta p \qquad (9)$$

the first factor of the right-hand side is recognized as $1/R^4$ and should therefore be minimized, and if the last factor, $t\Delta p$, constitutes a pre-assigned experimental boundary condition, then optimum performance will be obtained for the value of k which maximizes the middle term:

$$k_{\text{opt}} = \left(\frac{t - t_a}{t_a}\right)_{\text{opt}} = 3{\cdot}1 \qquad (10)$$

a very small departure from the previously[6] reported optimum k (3·3).

Δt has been used here to designate the band-width at mid-height, a rather popular usage. Another parameter, proposed by Keulemans[8], is the width intercepted on the base line by the tangents at the inflexion points of the band. I would like to urge that the already much-used terms 'band-width', or 'peak-width' and their symbol Δt, be continued in use in their established connotation of width of band at mid height, and that the term 'band intercept' or 'peak intercept', and the symbol $\Delta_i t$, be utilized to designate Keulemans's proposed measure.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A New Phenomenon of Electron Emission from Thin Mercury Films

When describing a new power rectifier valve utilizing line emission from the wetting edge of a mercury pool[1], the observation of a new phenomenon of emission was mentioned. At low loads, luminous patches had appeared for short instants parallel to the emission line in places on the anchor where film-like condensation had occurred. The luminous patches started on the film of condensate without visible initiation by a cathode spot from the emission line.

Emission into a mercury vapour arc from an extended area is in striking contradiction to the present concept of emission from liquid surfaces; hence, reproduction of the observed phenomenon over periods of sufficient length of time for proper observation promised a new way of approach to the mechanism of emission from liquid surfaces; further, it could yield valuable improvements for power rectifiers.

After more than three years of technological difficulties, a system satisfying stringent high-vacuum conditions has been produced. Fig. 1 shows its critical part under operating conditions. The emission system consists of a well-defined molybdenum surface (A) of about 1 cm.^{2} where the temperature can be adjusted at will between 20° and 70° C. This is enclosed in a discharge vessel with several electrodes and a reservoir, filled with about 1·5 cm.^{3} of liquid mercury. The walls of the discharge vessel, except the cathode surface A, are kept at a uniform temperature, variable between 20° and 350° C. Inflow of vapour towards the cathode system is thus determined by the temperature of the cathode and the vessel; excess condensate, if building up, returns in droplets to the reservoir. A protective conical screen (B) of thin molybdenum sheet extends from the temperature-controlled area down into the mercury reservoir, and prevents damage to the glass seal by the discharge. The discharge current covered the range 1–30 amp.

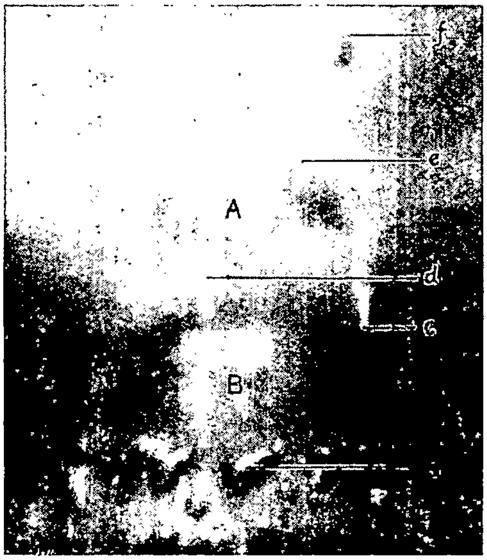

Fig. 1

A number of different phases of the emission, largely varying in appearance according to the specific operating conditions chosen, have been obtained, and also maintained for any desired length of time. These phases are: (i) the well-known free spots, running at random around on the spare mercury and the condensate droplets on surface A and cone B; (ii) transitional stages, consisting simultaneously of spots and fragments of lines moving at random with a preference for surface A; (iii) a multitude of streamers, emanating from the border between A and B, mostly extending on to A, but eventually also leading downwards on B, either alone or in combination with (ii); (iv) a uniform and steady glow-like thin sheath of small luminosity, evenly covering and clearly restricted to the surface part A, a phase for which the term 'film emission' will be used in the following.

The case shown in Fig. 1 is a transitional stage consisting of a short emission line (c), a number of streamers (d) and a patch of film emission (e); total emission current was 23 amp.; f is the ignition needle and g indicates large droplets of condensate.

Film emission, exclusively, can be obtained over a wide range of current densities; at very low values or with insufficient vapour density at the emission surface, the even spreading ceases, and contraction to lines, streamers or spots takes place. This behaviour suggests that the steady low current-density form of emission without evaporation represents the true and simple emission mechanism, while the more complex phases with random motion appear to be the unsuccessful attempts of the true mechanism to create those operative conditions which are required for the most favourable emission conditions.

It is too early to advance a theory of film emission. So far as observations go, they could be equally well interpreted by a current at the cathode composed overwhelmingly of electrons, or half of ions and half of electrons. In the first case the emission mechanism is a greater mystery than ever, because the current densities are several orders of magnitude too low for the mechanisms so far proposed. In the second case, one would have to postulate the release of about one electron per ion at the cathode surface, and a rather surprisingly efficient ionization mechanism in the region of cathode drop, which produces about one ion pair per electron. It is hoped that this will be decided directly by experiments now planned.

Because the film emission occurs at a definite place and is restricted to well-determined areas, clarification of the many rather conjectural assumptions made in the present theories of spot emission may be expected. One conclusion can be made already with certainty, namely, that emission from surfaces of liquid metal does not require intrinsically current densities of the order of thousands or ten thousands of amperes per square centimetre; neither does it require evaporation of the metal. For the further study of the emission of liquid surfaces, theories based on high current densities and evaporation of cathode material thus cannot claim universal validity.

My thanks are due to Prof. D. Gabor for putting at my disposal the resources of his laboratories at the

Imperial College of Science and Technology, London, and for his constant encouragement.

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Elastic Constants of Diamond

IN a recent communication in *Nature*, Krishnan, Chandrasekharan and Rajagopal[1] suggest that discrepancies between the determinations of the elastic constants of diamond may find an explanation in the enlarged scheme of elastic constants suggested by Laval, LeCorre, Viswanathan and Raman. In referring to the results of the experiments by Prince and Wooster[2], they suggest that "probably the theory of diffuse scattering of X-rays needs some modification in the light of the new theory of elasticity".

In the following communication, we indicate what changes the new theory of elasticity introduces into the interpretation of the measurements of Prince and Wooster, with the same notation as used in their paper, and using for the new theory the notation of the Indian school (which differs from the one originally introduced by Laval in that their d_{45} is his N_{47}, etc.). The change introduced by the new theory consists in the coupling together of d_{12} and d_{45} to form an inseparable pair of constants. For example, the experiments on a 110 reflexion enable the intensities of diffuse scattering from points along the [110] and [001] directions to be compared. The corresponding K-ratio, $K[110]_{220}/K[001]_{220}$, is in the old theory: $2c_{44}/(c_{11} + c_{12} + 2c_{44})$, and in the new theory: $2d_{44}/\{d_{11} + d_{44} + (d_{12} + d_{45})\}$. Similar changes are introduced into the other K-ratios.

On the old theory the following ratios for the elastic constants were found:

$$c_{12}/c_{11} = 0{\cdot}30 \pm 0{\cdot}02, \quad c_{44}/c_{11} = 0{\cdot}40 \pm 0{\cdot}02$$

We repeated the calculations using this time the formulæ of the new theory, and obtained for the new ratios:

$$(d_{12}+d_{45})/d_{11} = 0{\cdot}70 \pm 0{\cdot}02, \quad d_{44}/d_{11} = 0{\cdot}40 \pm 0{\cdot}02$$

The absolute value of the constant d_{44} was measured by Prince and Wooster using the intensity of Compton scattering as the standard. This gave a value of $(44 \pm 2{\cdot}5) \times 10^{11}$ dyn. cm.$^{-2}$. (These units will be used throughout this communication.) Using the above ratio for d_{44}/d_{11}, the value:

$$d_{11} = 110 \pm 11$$

is obtained. To proceed further, it is necessary to consider the bulk modulus of elasticity. The bulk modulus, k, is connected with the elastic constants by the equation:

$$k = (d_{11} + 2d_{12})/3$$

The value of k given by Adams[3] is 63, and by Williamson[4], 56. They lead to the following values of d_{12}:

$$\begin{aligned} d_{12} &= 39 \pm 6 \text{ (Adams)} \\ &= 29 \pm 6 \text{ (Williamson)} \end{aligned}$$

Now, $d_{12} + d_{45} = (0{\cdot}70 \pm 0{\cdot}02)d_{11} = 77 \pm 10$, and hence:

$$\begin{aligned} d_{45} &= 38 \pm 16 \text{ (Adams)} \\ &= 48 \pm 16 \text{ (Williamson)} \end{aligned}$$

Table 1 summarizes the results calculated according to the two theories:

Table 1

Old theory	New theory (with Adams's k)	(with Williamson's k)
$c_{11} = 110 \pm 11$	$d_{11} = 110 \pm 11$	110 ± 11
$c_{12} = 33 \pm 5$	$d_{12} = 39 \pm 6$	29 ± 6
$c_{44} = 44 \pm 2{\cdot}5$	$d_{44} = 44 \pm 2{\cdot}5$	$44 \pm 2{\cdot}5$
	$d_{45} = 38 \pm 16$	48 ± 16

Unfortunately, the uncertainty in the diffuse X-ray measurements, combined with the uncertainty in the measurement of the compressibility, make it impossible to establish a significant numerical difference between d_{44} and d_{45}. The same uncertainty in the compressibility affects all the calculations of d_{45} based on the dynamically measured $(d_{12} + d_{45})$. Consequently it is hard to see how any experimental proof can at this stage be given that the classical three elastic constants are insufficient for diamond, and that the four constants of the new theory have to be applied to it.

Quite apart from these experimental considerations, we have suggested in a recent communication[5] that in those cases where the Laval theory is applicable the number of independent elastic constants is not 45 but 39. For the Laue-group *m3m*, to which diamond belongs, the number of independent elastic constants turns out to be three, the same as in the classical theory.

Furthermore, it is difficult to accept the view that a separation of the results of methods that are all essentially dynamic, into 'static constants' and 'wave (dynamic) constants', can be made in the way suggested in the communication by Krishnan *et al.*[1].

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Errors in the Measurement of Film Thickness by Multiple-Beam Interferometry

THE Tolansky[1] method for the measurement of the thickness of thin films by multiple-beam interference techniques is now well established. Briefly, the film, the thickness of which is to be measured, is deposited on a flat, smooth substrate. The film should have a sharp edge so that a step is formed when the film and the adjacent substrate are coated with an opaque, highly reflecting metallic layer. The height of this step is measured by using the highly reflecting layer as one surface of an interferometer and viewing the multiple-beam fringe system by reflexion. Provided that the overlayer assumes the exact contour of the surface, this step-height will give the thickness of the film underneath.

There are two ways in which a sharp edge can be given to an evaporated film. Part of the substrate can be shielded during the deposition of the film, the shield being removed for the deposition of the overlayer. Alternatively, Scott, McLauchlan and

Sennett[2] have suggested that a sharp-edged step could be formed by gently drawing a not-too-sharp needle across the film prior to the deposition of the overlayer so that the film is removed, leaving a clear channel. However, they point out that care must be taken not to mar the substrate, in their case glass, marring being detected by the shape of the fringes.

In the course of investigating the adhesion of thin films to glass[3], it was found that serious errors could be made in the measurement of the thickness of the films when the method described by Scott, McLauchlan and Sennett was used. A number of metals were investigated, and in each case a film of the metal was deposited by evaporation on to a glass surface, a sharp edge being given to each film by covering part of the substrate during deposition. A number of channels was also made in each film by drawing a loaded steel point of smooth contour across the film surface. The point used in this investigation had a tip radius of 0·003 cm. and the load on the point was varied from 0 to 500 gm., the glass substrate tending to crack at this upper limit. The film and the substrate were then coated with an opaque silver layer and the film thickness and the depths of the channels or scratches were measured by viewing the multiple-beam interference fringes of equal thickness by reflexion. The results of one such set of measurements are shown in Fig. 1. In this case, the thickness of a chromium film was found to be 302 A., but the depth of the scratches made at loads greater than about 5 gm. were always greater than this value and increased with the load on the point. It has been shown[4] that plastic deformation of the glass substrate occurs when a load exceeding 2 gm. is applied to a point of tip radius 0·003 cm. pressing on it. It was found that the load required on the point to give a clear channel depended upon the adhesion of the metal film to the glass substrate and, for nearly all the films examined, a load greater than 2 gm. was required to give a clear channel. Therefore, deformation of the substrate would occur. Variation of the tip radius of the point would not eliminate the deformation of the substrate since it has been shown[4] that when the radius is decreased plastic deformation occurs at even lighter loads, whereas, when the radius is increased, a greater load is required to give a clear channel.

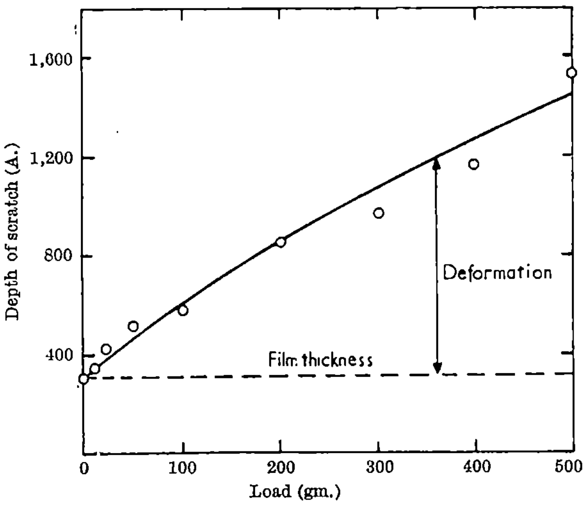

Fig. 1

Table 1

Metal	Load for clear channel (gm.)	Deformation of substrate (A.)
Silver	7	23
Gold	2	0
Copper	30	160
Aluminium	5	18
Antimony	—	—
Chromium	100	273

Scott, McLauchlan and Sennett measured the thickness of films of silver, gold, copper, aluminium, antimony and chromium. Table 1 shows the load on a point of radius 0·003 cm. required to give a clear channel in films of these metals together with the deformation of the substrate. It can be seen that if the depth of the channel was taken as the film thickness then very serious errors could occur, especially if the film adheres strongly to the substrate and a large load is required to give a clear channel. Scott, McLauchlan and Sennett have stated that a check was made between the film thickness and the depth of the channels and good agreement was found. However, it is possible that this check was made on a poorly adherent film such as silver, where the discrepancy would be within the experimental error, and this would account for the agreement.

It can be seen that even when a light pressure is applied to a point to give a channel by which the thickness of a film may be measured serious errors occur. These errors are even greater when excessive pressure has to be applied to the point to obtain a clear channel in a film which adheres strongly to the substrate. It appears that this method of forming a sharp edge to the film is unsatisfactory, and any measurements made using this technique should be treated with caution.

One of us (P. B.) wishes to thank the Metropolitan-Vickers Electrical Co., Ltd., for the provision of a postgraduate scholarship to undertake this work.

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Calculation of Absorption Peaks in Thin Metal Films

The refractive index of an absorbing medium can be written as $N = n - ik$, where n and k refer to the real and imaginary components of the complex quantity N. In this notation the value of n retains the velocity relationship of a simple non-absorbing medium, and k is the extinction coefficient. Another form of the equation has, however, found common usage, particularly with early workers in the field of metal optics ; in this form the refractive index N' is defined by $N' = n'(1 - ik')$. It can be seen that N is related to N' by the equations $n = n'$ and $k = n'k'$.

Confusion between these two forms has led to some errors in the evaluation of data recorded in standard

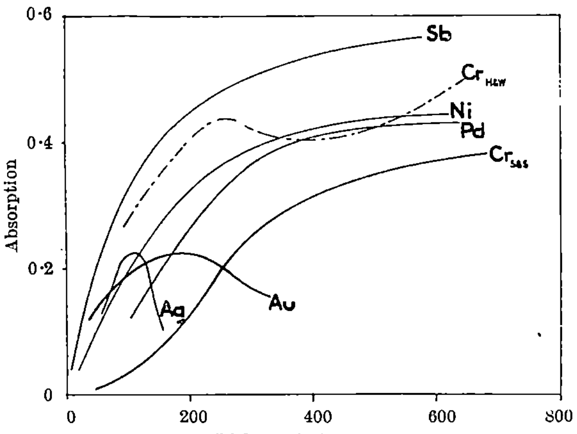

Fig. 1

reference books, for the quantities are commonly listed as n and k with no obvious correlating expression. Sennett and Scott[1] have been led into this type of error in an estimation as to the presence of peaks in the absorption/thickness curves for very thin metal films. Using Maxwell Garnett's equations[2], which are based on a theory of spherical aggregation within the metal films, they deduced that for a peak to be present in the absorption curve a quantity K, given by:

$$K = 2(k^2 - n^2)^3 - 9(k^2 - n^2)^2 + (12 + 8n^2k^2)(k^2 - n^2) - 4 - 12n^2k^2 \quad (1)$$

would have to be positive. Listed in Table 1 are the values that they obtained for K using values for the refractive indices of the metals listed in the International Critical Tables[3]. The variation of absorption of these metals with thickness is given in the full line curves in Fig. 1. From equation (1) it can be seen that the notation used by Sennett and Scott is that defined here by N, but the values of the refractive index components taken from the Tables correspond to $N' = n'(1 - ik')$.

Table 1

Metal	Wave-length	$N = n - ik$		K (ref. 1)	K (recalculated)
		n	k		
Silver	5890 A.	0·18	3·71	$+1{\cdot}5\times10^6$	$+3{\cdot}7\times10^3$
Gold	4000 A.	1·58	1·78	$-1{\cdot}07\times10^2$	$-49{\cdot}7$
	5800 A.	0·42	2·79	$+1{\cdot}7\times10^5$	$+5{\cdot}28\times10^2$
Copper	3950 A.	1·17	1·76	$-5{\cdot}3$	$+7{\cdot}44$
	6000 A.	0·56	3·08	$+5{\cdot}2\times10^4$	$+1{\cdot}09\times10^3$
Aluminium	5890 A.	1·28	4·69	$+2{\cdot}0\times10^3$	$+1{\cdot}87\times10^4$
Antimony	5890 A.	3·04	4·95	$-2{\cdot}6\times10^3$	$+3{\cdot}01\times10^4$
Nickel	5890 A.	1·79	3·33	$-35{\cdot}0$	$+1{\cdot}05\times10^4$
Palladium	6000 A.	1·92	2·52	$-2{\cdot}7\times10^2$	$+2{\cdot}32\times10^2$
Chromium	6080 A.	3·28	4·30	$-4{\cdot}4\times10^3$	$+4{\cdot}28\times10^4$

The values of K have been recalculated, using the corrected values for the refractive indices (Table 1, column 6), and little agreement has been found between the sign of K and the presence of absorption peaks. Furthermore, it is not considered likely that properties of this type, depending as they do on the conditions of preparation of the films, could be forecast with any accuracy from bulk metal values of refractive index. The Maxwell-Garnett model assumes the presence of a large number of discrete, spherical particles separated by free space, and as Sennett and Scott have already shown in the case of silver films[1] this holds only for very small values of film thickness. Thicker films show a much more continuous structure, which may or may not possess bulk properties. The transition from one structure to the other has been shown by a variety of experimental methods[4,5], and in all cases the properties being measured change widely with film thickness. Where, however, a film could be induced to grow as a series of perfect monolayers, each possessing the same optical properties, then the refractive index would remain constant, and for large thicknesses bulk material would be obtained. For this type of model structure measurements made on the bulk material would give valid results for thinner films.

In the course of an investigation into the structure of evaporated chromium films it has been shown that the optical constants vary widely with the thickness of the films[6], and that the effective refractive index of the complete film is not at all like that of the surface. Indeed, close agreement has been found between the effective refractive index of the surface layer of a thick film of chromium and of the bulk metal[7]. In this investigation the absorption curve was obtained and this is shown dotted in Fig. 1. The refractive index of the surface layer using the notation $N = n - ik$ was measured as $1{\cdot}18 - 0{\cdot}944i$, and the effective refractive index of the whole film was measured as $0{\cdot}64$–$1{\cdot}25i$; the former gave a value of K of $-30{\cdot}2$, and the latter $-0{\cdot}72$. As the growth has been shown not to follow the Maxwell Garnett pattern, little agreement could be expected and a peak was obtained in the absorption curve. The particles of these chromium films have, however, been found to follow more closely the David–Schopper[8,9] model of ellipsoids of revolution, but in this case differentiation of the equation for the absorption in order to determine the new form for equation (1) appears impossibly complex.

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Stability of Evaporated Films

It has often been assumed that metal films condensed at a low temperature (−183° or −195° C.) are stable after warming several times to around room temperature. The recent work of Klemperer and Stone[1] and Rosenberg[2] on evaporated nickel and cleaved germanium surfaces respectively suggests that physical changes occur at the surface during oxygen chemisorption. Harrison and Morrison[3] have postulated that similar changes occur when sodium chloride surfaces, formed by evaporation, are kept *in vacuo* at room temperature. These physical changes result in a decrease in area of the respective surfaces, Klemperer, Stone and Rosenberg detecting the process by the physical adsorption of krypton, Harrison and Morrison deducing it from results obtained by an isotopic exchange technique.

In this Laboratory a fundamental study of the interaction of oxygen with iron surfaces is being carried out, and it is therefore important to determine whether this change in surface area can occur with evaporated iron films after the usual warming and cooling process has been repeated several times.

Chemically 'clean' surfaces were prepared by evaporation in a high-vacuum greaseless apparatus. An iron film condensed at −195° C., of weight 6 mgm. and apparent area 130 cm.^{2}, was warmed several times to room temperature (with intermittent cooling to −195° C.) before starting adsorption experiments.

Krypton isotherms determined at −195° C. on a clean surface and on the same one having chemisorbed 220 × 10^{-3} cm.^{3} (S.T.P.) oxygen at an immeasurably fast rate at an equilibrium pressure of 10^{-5} mm. and 24° C. are shown in Fig. 1. (This quantity of oxygen is the maximum that the iron surface would adsorb in this manner; further oxygen uptake occurred at a measurable rate.) Using the theory in ref. 4, these isotherms correspond to krypton monolayers of 57 × 10^{-3} cm.^{3} (S.T.P.) and 33 × 10^{-3} cm.^{3} (S.T.P.) for the clean and oxidized surfaces respectively. The fast chemisorption of oxygen has thus resulted in a decrease of the surface area to 0·23 of its original value.

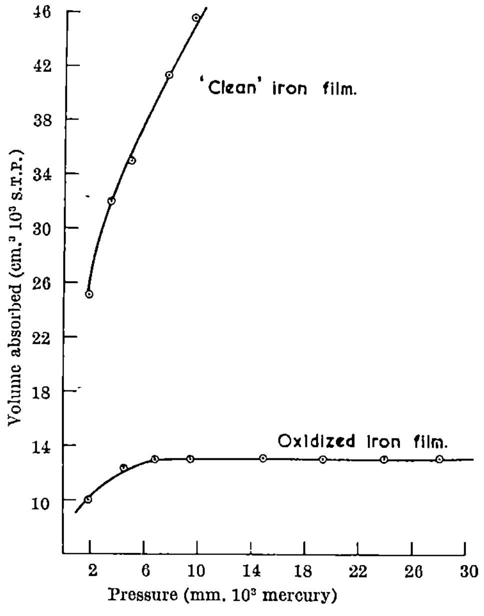

Fig. 1. Krypton isotherms at −195° C.

The effect of 'ageing' a clean iron film *in vacuo* at 24° C. was then considered. An iron surface, prepared as described above, was kept at a pressure less than 10^{-6} mm. at 24° C. and the surface area measured after various time-intervals. It was shown that the surface decreased in area with time. This effect is, however, of a smaller magnitude than that observed during oxygen chemisorption, the area decreasing to 0·72 of its original value in 20 hr.

It is evident that such changes in surface area must be taken into account in interpreting results with evaporated surfaces. A fuller account of this work will be given elsewhere. This communication is published by permission of the Director of the National Chemical Laboratory.

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A Calorimeter for Determination of Heats of Wetting

For most problems connected with the properties of surfaces a need is felt for an apparatus which permits a rapid determination of the heats of adsorption. A suitable calorimeter was constructed, therefore, to determine the heat evolved when solid surfaces come into contact with different amounts of liquids. The calorimeter can determine heats of adsorption as low as 0·001 cal./gm. and the time of each determination is of the order of 30 min.

The apparatus consists essentially of a cell filled with an adsorbent, thermocouples placed in direct contact with the adsorbent, and a suitable jacketing arrangement. The cell is kept at a constant temperature and a liquid is allowed to flow through the cell at a constant rate. When the liquid comes into contact with the solid, a temperature rise is produced and measured by the thermocouples. The heat of adsorption of the liquid on the solid is evaluated by reproducing the temperature rise by passing a known current through a heater situated in the centre of the cell. Heats of replacement of one liquid by another liquid on a given adsorbent may be estimated by allowing a carrier liquid to flow through the cell at a constant rate and introducing into this liquid the second material.

In Fig. 1 a calorimeter with 13 thermocouples is shown. An ice bath encloses the cell containing adsorbent. A capillary jet is attached to the end of the separating funnel containing the carrier liquid and the bore of the jet controls its rate of flow. A small plug of cotton-wool retains the adsorbent in the cell. The hot junctions of the thermocouples are situated immediately above the plug and are sealed, by means of a casein glue, into the wall of the cell. The ends of the thermocouples are only slightly protruding from the wall and are in direct contact with the powdered solid. A coil of nichrome wire possessing a resistance of 10 ohms is situated in the centre of the cell. The coil is used to reproduce the effects taking place during adsorptions, by passing through it a small current from a source of constant known voltage, for a given length of time.

A glass tube is connected directly to the cell and extends to a special attachment which is used for introducing small quantities of unknown substances from a micrometer syringe, while a carrier liquid flows continuously through the apparatus. Enamelled copper and constantan wires (32 S.W.G.) are used for the thermocouples. The thermojunctions are made by twisting the bare ends of the wires together and brazing with the minimum amount of silver. The wires from the hot junctions pass out of the glass jacket, through holes in the rubber bung to the outside of the jacket, where the cold junctions come into direct contact with the ice. The cold

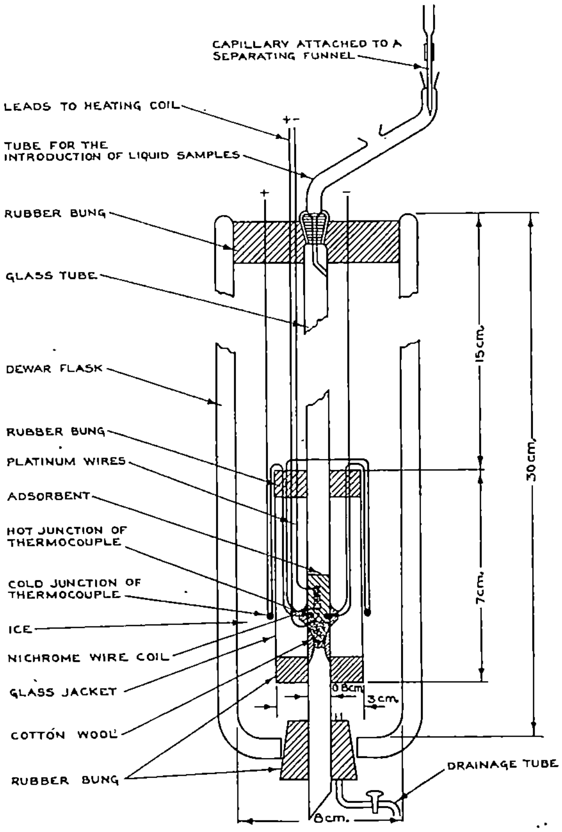

Fig. 1

junctions are held in position by a series of rubber bands. The ends of the two connecting copper leads are joined to either a galvanometer or a potentiometric recorder.

An illustration of the results that can be obtained with the calorimeter is given by the temperature rises produced by wetting of silica gel by a number of organic liquids. In Fig. 2 the temperature of the cell is plotted against the time, and the peaks shown represent the increases of temperature produced by the successive wetting of the adsorbent by *n*-decane, 1-dodecene, *m*-xylene, α-methylnaphthalene, *m*-cresol, *iso*propyl alcohol and acetone. In each case 0·05 ml. of a substance was injected into the carrier liquid consisting of *n*-heptane. (For acetone only 0·025 ml. was injected.) It is noteworthy that *n*-decane gives a measurable response when the carrier liquid is another paraffin, *n*-heptane. Substances of different chemical type give a much greater response.

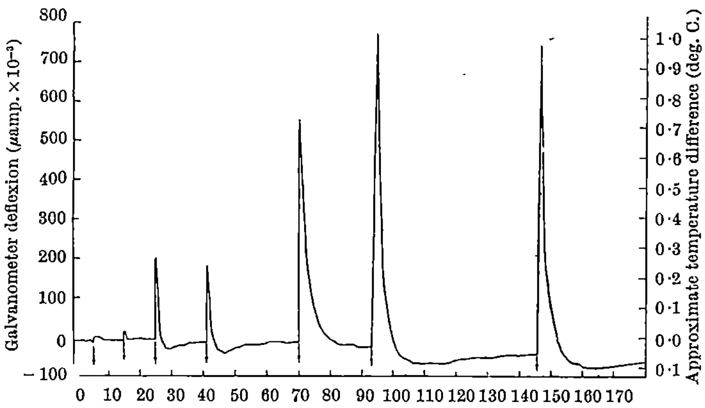

Fig. 2. Temperature rises produced by various substances. Peaks (indicated by arrows) from left to right: decane, 1-dodecene, *m*-xylene, α-methylnaphthalene, *m*-cresol, *iso*propyl alcohol, acetone

This work was initiated in the laboratories of Benzole Producers, Ltd., and is the subject of Patent Application No. 38305/57 in their name.

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Capillary-tube Viscometry with Negligible Kinetic Energy Effects

The uncertainties associated with the kinetic energy correction in conventional capillary-tube viscometry result in considerable inaccuracy and inconvenience. These uncertainties arise from the dependence of the kinetic energy 'constant', B, on flow-rate and on the form of the capillary ends, B being defined by the equation:

$$\nu = Ct - B/t$$

where ν is the kinematic viscosity, t is the time of flow and C is the principal calibration constant. The significance of the kinetic energy term in the accurate measurement of the viscosity of liquids using capillary viscometers was emphasized at the recent symposium[1] arranged by the Institute of Petroleum and the British Society of Rheology.

In the course of work carried out during the past two years at the National Standards Laboratory, Sydney, capillary viscometers of both U-tube and Ubbelohde types have been developed in which the kinetic energy effect is entirely negligible. Since the viscometers are but little more difficult to construct than those employed in the usual standard procedures, as exemplified in B.S.S. 188 : 1957, they could with profit be adopted for those procedures.

The practical elimination of the kinetic effect is achieved by forming a gradual flare, generally a few centimetres long, at each end of the capillary tube. The flares may be so long as to run together at the centre of the tube, which then possesses no parallel part. Using viscometers with the capillary ends flared in this way, it has been found that the value of B is reduced to less than 0·02 of its value for otherwise similar conventional viscometers used at the normal flow-rates. In a series of measurements at higher flow-rates it was found that the kinetic energy effect could only be detected with certainty at flow-rates corresponding to Reynolds numbers exceeding three times the highest values encountered in conventional viscometry. At much higher flow-rates the value of B for the flared capillaries used in these experiments increased monotonically with Reynolds number, reaching, for example, about half the usual value at a Reynolds number of a thousand.

The long flare is readily produced by applying pneumatic pressure to a parallel capillary tube, with the end sealed, while it hangs in a temperature gradient in a furnace. A uniform temperature gradient is suitable.

A detailed account of this work has been submitted for publication elsewhere.

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Temperature and Turbulence in Quiescent Prominences determined from Line-widths

Some years ago, one of us attempted to determine the kinetic temperature of atoms and a possible turbulence in some quiescent prominences[1]. Since at that time the different lines of a prominence had to be exposed one after the other and since only Hβ and D3 could be used for the purpose, it seemed desirable to make further observations of solar prominences with improved equipment[2].

The present observations were made with our tower telescope ($f = 24$ m.) using a Bausch and Lomb concave grating (radius of curvature 665 cm.). The prominences were guided on to the slit of the spectrograph (height of the slit 0·6 mm.) by using a Lyot Hα filter[3]. The following lines—arising with good approximation in an optically thin layer—could be exposed simultaneously : λ 8542 and (in some spectra) λ 8498 of Ca+, λ 5875 of He, λ 4340 and λ 3970 of H, the Balmer lines in the second order, the other lines in the first order. Since the molecular weight of calcium is forty times greater than that of hydrogen, the separation of temperature and turbulence is fairly certain. All line-widths have been corrected for the finite resolving power of the spectrograph.

Table 1 gives the results for ten quiescent prominences. The temperatures and the turbulent velocities are mean values computed according to the method of least squares, giving double weight to the widths of the Balmer lines. The different values given for one and the same prominence belong to different exposures. The scatter expresses, therefore, not only the uncertainty of the measurements but also local differences in temperature and turbulence within a prominence, since it was not always possible to place the same spot of the prominence on the slit of the spectrograph for all exposures.

The kinetic temperatures—significantly higher than the excitation temperatures derived earlier[1]—and the turbulence in quiescent prominences are probably of the same order of magnitude as in the lower chromosphere. A slight but significant negative correlation ($r = -0{\cdot}52$, $n = 39$) exists between kinetic temperature and turbulence. This correlation is somewhat more conspicuous if the H and He lines are treated separately ($r = -0{\cdot}64$, $n = 35$), and is absent if the He and Ca+ lines are treated separately. From a physical point of view the negative correlation is likely to be a pseudo-correlation, suggesting that the Balmer lines arise in a different layer of a prominence from the D3 line of He and the Ca+ lines.

A detailed discussion of our improved observations will appear shortly in the *Nachrichten der Akademie der Wissenschaften in Göttingen, Math.-Phys.-Klasse*.

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Electron Spin Resonance in Carbons : a New Oxygen Effect

Ingram and Tapley[1] and Uebersfeld and Erb[2] have observed that electron spin resonance in certain carbons can be affected by oxygen. Austen and Ingram[3] showed that the electron spin resonance signal given by a carbon in vacuum may be (*a*) broadened, (*b*) reduced in total integrated intensity, by exposure to oxygen at room temperature. In both cases, it was found possible to restore the signal to the value it possessed in vacuum by outgassing the sample for a few minutes at room temperature.

Table 1

U.T. 1957	T_{kin} (deg.K.)	v_{turb} (km./sec.)
May 1 6h. 24m.–6h. 35m. W., 40° S.*	4,800 5,000 4,800	9·2 9·0 9·2
May 1 7h. 00m.–7h. 14m. E., 30° S.	6,500 5,900	4·9 5·0
May 9 13h. 45m.–14h. 00m. W., 63° S.	9,300 8,600 5,500 5,900 6,000	4·9 5·7 6·7 7·1 6·3
May 9 14h. 30m.–14h. 45m. E., 33° N.	5,800 5,200 4,600 4,500	7·6 7·5 7·6 8·6
May 10 8h. 10m.–8h. 15m. E., 33° N.	7,500 6,900 6,300 4,500	6·5 6·7 6·1 6·4
May 11 9h. 45m.–10h. 00m. E., 35° N.	7,000 7,100 5,200 5,100	6·3 6·1 6·1 5·7
May 15 6h. 35m.–6h. 45m. E., 10° N.	6,300 7,000 8,200	3·9 3·9 3·6
May 25 8h. 25m.–8h. 45m. W., 10° S.	6,300 7,000 6,800 6,000 5,500	3·6 4·8 3·8 3·9 4·8
June 13 6h. 12m.–6h. 21m. E., 40° N.	7,600 7,900 7,300 6,500	5·6 4·9 4·9 5·0
June 13 16h. 04m.–16h. 30m. W., 0°	8,800 5,900 5,000 7,700 6,600	6·6 7·3 7·3 6·1 7·0

* Position of prominences according to "Daily Maps of the Sun", Fraunhofer Institut, Freiburg im Breisgau.

Table 1

	Acidity of carbon (micro-equiv./gm.)	Total free radical concentration (free spins/gm.)	Gas produced by decomposition (micromole/gm.)	
			CO_2	CO
Unoxidized carbons (prepared by carbonization at 700° C. for 1 hr. in vacuum)				
Cellulose	350	$10·4 \times 10^{19}$	—	—
Sucrose	190	$23·4 \times 10^{19}$	—	—
Polydivinylbenzene	170	$18·5 \times 10^{19}$	—	—
Starch	110	$18·4 \times 10^{19}$	—	—
Oxidized carbons (Unoxidized carbons heated in air)				
Cellulose (½ hr. at 300° C.)	1,450	$< 10^{18}$	—	—
Sucrose (3 hr. at 350° C.)	2,640	$7·5 \times 10^{19}$	—	—
Polydivinylbenzene (½ hr. at 350° C.)	3,680	$6·3 \times 10^{19}$	—	—
Starch (2 hr. at 350° C.)	3,630	$8·6 \times 10^{19}$	—	—
Neutralized carbons (oxidized carbons neutralized with 0·26 *N* sodium hydroxide at room temperature)				
Cellulose	—	$6·9 \times 10^{19}$	—	—
Sucrose	—	$10·2 \times 10^{19}$	—	—
Polydivinylbenzene	—	$9·5 \times 10^{19}$	—	—
Starch	—	$12·8 \times 10^{19}$	—	—
Decomposed carbons (oxidized carbons reheated in vacuum)				
Cellulose (to 550° C.)	860	$5·3 \times 10^{19}$	835	910
Sucrose (to 550° C.)	1,230	$12·8 \times 10^{19}$	1,020	930
Polydivinylbenzene (to 580° C.)	970	$13·5 \times 10^{19}$	1,680	1,740
Starch (to 570° C.)	2,270	$12·8 \times 10^{19}$	1,370	760

We have observed an oxygen effect with carbons which we believe to be quite distinct from that described by previous workers. In this case, oxidation of the carbon at more elevated temperatures produced a reduction in the total concentration of free radicals, which could not be restored by outgassing the sample at room temperature.

Carbons were prepared by heating cellulose, sucrose, starch, and pre-oxidized polydivinylbenzene in vacuum to 700° C. After cooling in vacuum, these carbons were oxidized by heating in air at a temperature in the region of 300–400° C.; details of the oxidation treatment are given in Table 1. After a preliminary outgassing for 24 hr. at room temperature, the oxidized carbons were reheated in vacuum. This treatment decomposed some of the surface oxide with the production of a volume of gas which, on analysis, proved to be a mixture of carbon monoxide and carbon dioxide.

The formation and decomposition of acid surface oxide[4] was followed by studying the sorption of sodium hydroxide by each of the carbons. 1 gm. of carbon was shaken for 24 hr. with 30 ml. of 0·26 *N* sodium hydroxide and the final concentration of alkali in the supernatant solution found by titration with dilute acid, care being taken to exclude atmospheric carbon dioxide. A specimen of the neutralized carbon was dried at 100° C. and examined as described below.

The electron spin resonance of the unoxidized, oxidized, neutralized and 'decomposed' carbons was examined using a standard X-band microwave spectrometer. All specimens were prepared for electron spin resonance measurements by outgassing at room temperature for 20 hr., heating at 200° C. for 1 hr. and finally sealing in vacuum. It seems certain, therefore, that the oxygen effect described by previous workers[1–3] was not occurring in these experiments.

In general, the unoxidized specimens possessed large electron spin resonance signals (Table 1). When oxidized, the samples showed a large increase in acidity, while the total concentration of free radicals was considerably reduced. By heating the oxidized sample in vacuum at about 550° C., some of the surface oxide was decomposed and the signal was partially restored. Neutralization of the oxidized material with sodium hydroxide also caused a partial recovery of the electron spin resonance signal.

We attribute the reduction in concentration of total free radicals on oxidation to the formation of surface oxide, as indicated by the increased acidity of the specimens. The partial recovery of the electron spin resonance signal on reheating the oxidized carbon provides further confirmation of the idea. The adsorbed oxygen appears to be more tightly bound than that encountered by Austen and Ingram, since it was not removed during the outgassing treatment but only at higher temperatures, as a mixture of carbon monoxide and carbon dioxide. It seems possible that, in the earlier work, the oxygen molecules were weakly adsorbed as a charge-transfer compound of the type described by Mulliken[5], whereas our results appear to be due to the formation of covalent oxides. The possibility is therefore raised that the electron spin resonance of carbons prepared from materials containing oxygen may be dependent, to some extent, on the proportion of oxygen retained by the structure during carbonization. The behaviour of sodium hydroxide in partially restoring the concentration of radicals of oxidized carbons is not yet fully understood, but further work is being carried out to clarify this effect.

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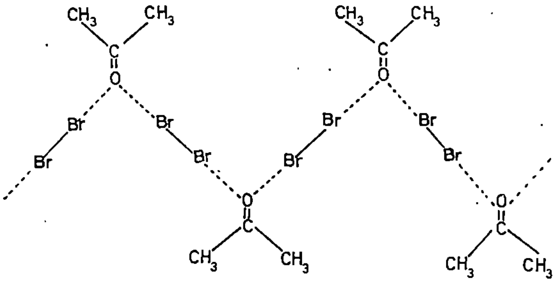
Halogen-Molecule Bridges in Solid Addition Compounds

One very striking result obtained from X-ray work on solid addition compounds in which halogen molecules act as electron acceptors is the fact that both halogen atoms of a particular Hal_2 molecule may simultaneously be linked to donor molecules. Thus, in the 1 : 1 compounds formed by 1,4-dioxan and bromine (or iodine) endless chains are present which are built up of alternating dioxan and halogen molecules and containing linear O—*Hal*—*Hal*—O arrangements[1]. Moreover, in the solid 1 : 1 compound formed by benzene and bromine, straight chains of alternating benzene and bromine molecules have been established[2]; the benzene-ring planes are parallel and the bromine molecules symmetrically arranged on the common chief axis of the benzene rings. Until quite recently it was uncertain whether more than one single halogen-molecule bridge could actually start from one particular electron donor atom. In the case of oxygen and other donor atoms possessing more than one lone electron pair such an arrangement would not appear to be impossible.

The 1 : 1 compound between acetone and bromine actually affords an example of this kind. According to new results the crystals of this compound contain endless chains of the type :



Here, both lone electron pairs belonging to a particular keto oxygen atom evidently take part in halogen bond formation. The keto carbons and oxygens and the bromine atoms belonging to the same chain are coplanar and the O—Br—Br—O arrangements strictly linear. The methyl carbons do not appear to lie exactly in the plane of the other atoms of the chain. This is probably so because otherwise the distances between methyl carbons and bromine atoms would be energetically unfavourable. The Br—Br distance appears to be very little different from the distance observed in the free molecule (2·28 A.). The O—Br distance was found to be 2·82 A. and the Br—O—Br angle nearly 110°. Details of the structure determination will be published elsewhere. The space group is $C2/c$ and the lattice parameters are as follows :

$a = 7{\cdot}12$ A. $b = 7{\cdot}48$ A. $c = 12{\cdot}90$ A. $\beta = 111{\cdot}5°$

The unit cell contains four molecules.

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Boron-10 Abundance in Nature

The most reliable values for the isotopic abundance of boron-10 in naturally occurring minerals have been derived from mass spectrometer measurements. Results quoted by different workers, however, range from 18·4 to 19·9 per cent boron-10, and it is not difficult to find possible causes for the variation. Most of the measurements have been made with boron trifluoride, which is a difficult compound to handle in a mass spectrometer, since memory effects and interference from impurities can give very erratic and incorrect results ; even when there are no errors of this kind, it is still possible for results to be biased by mass discriminations in the mass spectrometer, and no reported attempts have been made to standardize the results in any way. Insufficient care when preparing samples from the natural minerals could also cause errors arising from discrimination with respect to one isotope. The possibility of variation of the abundance of boron-10 in Nature has been investigated by Parwel *et al.*[1], who examined a large number of minerals and found only a slight difference for boron obtained from sea water.

Among the more recently reported results, Osbergaus[2] quotes a constant value of 19·6 per cent boron-10 for a small number of minerals examined. Panchenkov and Moissev[3] quote 18·4 per cent boron-10 for (presumably industrially prepared) boron trifluoride. Kilpatrick *et al.*[4] claim to have eliminated their mass discriminations and quote 18·8 per cent boron-10 for industrially prepared boron trifluoride.

In order to make a check on mass spectrometer discriminations and to obtain a more accurate figure for the natural abundance of boron-10, we have prepared standard samples of boron trifluoride with known isotopic content. Primary standards were prepared by blending enriched and depleted boron trifluoride in known proportions, and these were compared with bulk secondary standards using a mass spectrometer. We later compared the appropriate secondary standard with a sample of boron trifluoride which had been carefully prepared from naturally occurring boron. This sample has been shown by Parwel *et al.*[1] to contain boron with the same isotopic composition as that obtained from all the other minerals they examined ; we are indebted to H. von Ubisch of A. B. Atomenergi, Stockholm, for supplying this sample. Our results show that the mass spectrometer discriminations, expressed as a fraction of the isotope ratio, are the same for both enriched and natural boron trifluoride, as might be expected. The naturally occurring boron sample was found to contain (19·3 ± 0·1) per cent of boron-10.

A more detailed account of the preparation of the isotopic standards and of the mass spectrometer measurements will be published elsewhere.

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Surface Concentrations of Manganese Nodules

Manganese nodules were investigated during the Downwind Expedition, a part of the International Geophysical Year programme of the Scripps Institution of Oceanography of the University of California. Attempts were made to collect bottom photographs, cores and dredge hauls in the same areas, to measure the distribution at the surface and in depth, and to obtain large samples for physical and chemical analysis.

Although nodules were sampled and photographed in various places along the expedition track between California, Tahiti and South America, the greatest concentration was found on the red clay bottom deeper than about 4 km. in the south-western Pacific Basin. Nodules had been discovered in the basin by the *Challenger* eighty-five years before. The two ships of the expedition followed the track of

Table 1. DOWNWIND EXPEDITION BOTTOM PHOTO STATIONS SHOWING ABUNDANT MANGANESE NODULES

Station No.	Region	Latitude	Longitude	Depth in metres	Per cent of bottom covered	gm.cm.$^{-2}$
DWP-2	Baja Calif. Smt. Prov.	10° 25′ N.	130° 35′ W.	4,712	Abundant	
DWP-5	French Polynesia	18° 31′ S.	141° 23·5′ W.	4,080	Abundant	
DWP-8	French Polynesia	21° 37′ S.	147° 40′ W.	4,684	26	2½
DWP-10	South-western Pacific Basin	32° 08′ S.	140° 30′ W.	4,754	23	1
DWP-11	South-western Pacific Basin	42° 50′ S.	125° 32′ W.	4,560	46	4

the *Challenger* and explored a narrow band about 2,700 km. long in a south-easterly direction from latitude 25° S. to 45° S. in the eastern part of the basin. Two bottom photographs, twenty-three gravity cores and two dredge hauls were obtained. Photographs (Fig. 1) indicate that about a quarter to a half of the sea floor in this basin is covered with manganese nodules and that the weight per unit area is about 1–4 gm. cm.$^{-2}$ (Table 1). The surface concentration was determined by standard statistical procedures. Density of the nodules is about 2·0 gm. cm.$^{-3}$. The scale of the photographs is known, and the volume of the nodules can be estimated because the smaller nodules are roughly spherical and the lengths of their shadows give a scale for measuring the thickness of slab-shaped nodules. The sizes computed agree reasonably closely with the sizes dredged.

The group of cores gives less definite evidence of the fraction of the bottom covered with nodules in the south-western Pacific Basin but it provides a means of interpolation between the widely separated camera stations. Some twenty-three gravity cores contained samples as follows: six sediment but no nodules; four manganese oxide fragments in core nose; four small nodules only; nine sediment and nodules including eight with nodules at surface. Omitting one smaller core for uniformity, each of twenty-two cores has a cross-sectional area of 18 cm.^{2}. The four cores with manganese oxide fragments may be assumed to be hits on large nodules each with an area of 18 cm.^{2}. The thirteen cores with nodules alone or nodules and sediment have fifteen nodules at the surface with an average diameter of approximately 1 cm. These figures indicate one-fifth of the bottom is covered with nodules along the transverse. Consequently, the average coverage of nodules indicated by coring is about the same as the minimum shown on photographs. The average coverage from coring would be greater if four other coring attempts were counted as hits on large nodules. On each of these a ball-break indicated that the cores hit bottom, but no sample of any kind was obtained in the cores. However, nodules were indicated by black streaks and scratches not only on corers but on the camera and temperature probe. Similar streaks on equipment were observed in this area during the *Challenger* Expedition[1] and interpreted as indicating very abundant nodules.

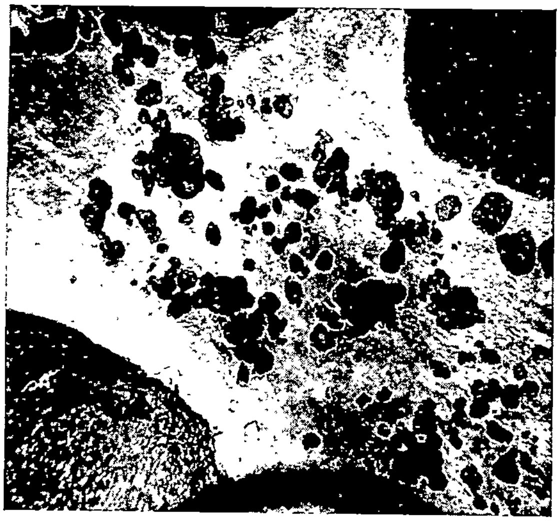

Fig. 1. Photo *DWP*-11. Area about 6 m.^{2}

Nodules are not limited to the surface of the sea bottom. Of fifteen cores that penetrated deeper than 11 cm., three contained nodules at depths of 8–11 cm. Of thirteen cores penetrating to 72 cm., six had nodules 48–72 cm. below the surface. No other nodules have been found in a maximum penetration of 140 cm. One core penetrated to approximately 47–50 cm. where a small nodule was lodged in the core catcher. This is the only core which ceased penetrating when it reached one of the nodule-rich zones. Consequently, there is no positive indication that large nodules (which would stop the corer) occur anywhere except at the surface. Moreover, some of the cores may have hit the bottom more than once, with the result that some nodules that appear to be buried in sediment were actually at the surface.

Manganese nodules are a potential resource so that an estimate of the amount in the south-western Pacific Basin may be of interest. The U.S.S. *Enterprise* took a latitudinal line of samples by sounding lead across the basin at about 50° S. Several records of 'black specks' and one 'black stone' may indicate manganese nodules or fragments. No other samples are available, and it is only an assumption that the concentration of nodules found along the Downwind track is characteristic of the whole basin. The basin deeper than 4 km. has an area of roughly 10^{7} km.^{2}. If the concentration of nodules is uniform at 1 gm. cm.$^{-2}$, the total weight of the surface deposit is 10^{17} gm. Average chemical analyses of Pacific nodules suggest that iron and manganese are present in the deposit in amounts of 10^{16} gm., and cobalt, copper and nickel and rare earths each amount to 10^{15} gm.

Dredge hauls and cores show that nodules are distributed within perhaps 5×10^{7} km.^{2} of the Pacific Basin, but little is known about the concentration per unit area. Photograph *DWP*-8 in French Polynesia indicates that nodules cover about a quarter of the surface, but the photograph is oblique and subject to greater errors of interpretation than photographs *DWP*-10 and -11 (Fig. 1). Similar concentrations are suggested by photographs in other areas, but the nodules are partially covered with sediment and only rough estimates are justified. Nevertheless, the scanty evidence available suggests that manganese nodules cover a considerable fraction of the deep sea floor in many parts of the Pacific Basin. This circumstance presents a puzzle, because the upward growth of nodules may be one or two orders of magnitude slower than commonly accepted average deposition rates of sediment in the deep sea[2].

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Diffusion of Zinc in Gallium Arsenide

ZINC is an acceptor impurity in gallium arsenide with small ionization energy. If it is the predominant impurity and is present in low enough concentration, then the Fermi-level will lie above the zinc-levels and the zinc atoms will nearly all be ionized, that is, they will have accepted an electron. As the zinc concentration increases, the Fermi-level will descend into the valence band and the proportion of ionized atoms becomes small. Since the speed of diffusion of an atom will be different in its ionized and in its un-ionized state the diffusion coefficient will depend upon concentration.

The conditions under which one might observe this effect are as follows. We define a critical concentration N_0 of zinc atoms above which most of them will not be ionized, and below which most of them will be. Then we require the surface concentration to be greater than N_0 and the intrinsic number of holes and electrons to be small. These conditions can easily be satisfied for zinc diffusing into gallium arsenide at 1,000° C. We have worked out the theory of this system and in Fig. 1 we show a theoretical curve of impurity concentration as a function of distance into a specimen when the diffusion is into a semi-infinite block with constant surface concentration of impurity. Also shown are some experimental points obtained by a radioactive tracer method. The agreement between theory and experiment is seen to be quite good. The most interesting feature of the curve is the change in slope when the concentration is equal to N_0, giving a very steep diffusion front, and this effect will obviously be of importance in design problems.

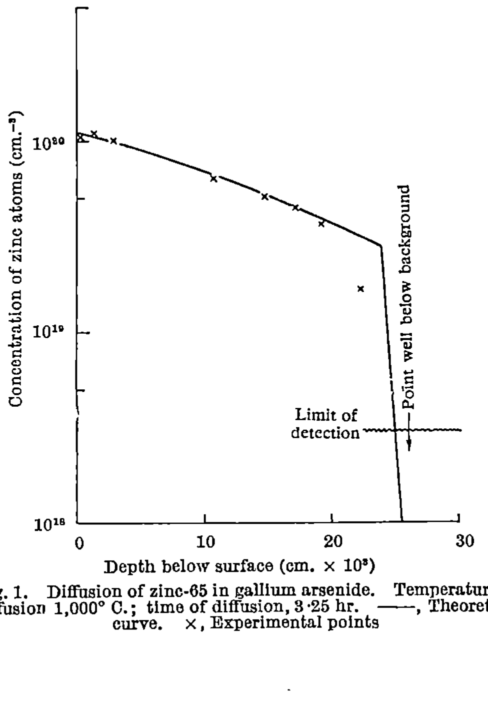

Fig. 1. Diffusion of zinc-65 in gallium arsenide. Temperature of diffusion 1,000° C.; time of diffusion, 3·25 hr. ——, Theoretical curve. ×, Experimental points

Two further points emerge which may be stressed. First, we can find from our analysis of the experimental results the diffusion coefficient of zinc in both the ionized and the un-ionized states. Preliminary measurements show that at 1,000° C. the diffusion coefficient of un-ionized zinc is about thirty times greater than that of ionized zinc. This is reasonable, since when the zinc has accepted an electron it is presumably more tightly bound and is also larger. We hope to find the two coefficients as a function of temperature in order to compare the activation energies. Secondly, the effects are particularly pronounced in the zinc–gallium arsenide system because the conditions enunciated above are well satisfied, but they may occur in other systems to a lesser degree and produce apparent anomalies. For example, it is quite possible to have an apparently normal concentration – depth curve which when extrapolated to the surface yields a value for the surface concentration considerably different from the true value. Full details of the theory and experiments and a discussion of these possibilities will be published elsewhere.

Acknowledgment is made to the Admiralty for permission to publish this communication.

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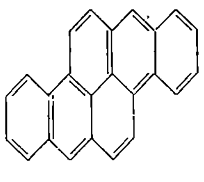
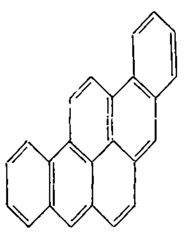
Presence of 3 : 4-8 : 9-Dibenzpyrene in Coal-Tar

ALTHOUGH several carcinogenic hydrocarbons of varied potency have been isolated from coal-tar, including 1 : 2-5 : 6-dibenzanthracene, 3 : 4-benzpyrene[1], and 1 : 12-benzperylene[2], it is known that the presence of such substances is not sufficient to account for both the qualitative and the quantitative carcinogenicity of coal-tar itself. This consideration warranted the search for further carcinogens in coal-tar, particularly in pitch fractions containing the more condensed aromatic hydrocarbons, and especially in view of the considerable carcinogenic activity of several hexacyclic hydrocarbons such as 3 : 4-8 : 9-(I)[3] and 3 : 4-9 : 10-dibenzpyrene (II)[4]. Schoental[5] has recently reported the presence of (II) in a carcinogenic fraction of coal-tar, and this prompted the present report of the isolation of another potent carcinogen, 3 : 4-8 : 9-dibenzpyrene, from similar material. This hydrocarbon, which was isolated in small amounts by the usual fractionation and chromatographic methods, from the fractions boiling above 500° C. of various samples of coal-tar pitch,



(I)



(II)

was identified by direct comparison of melting point and ultra-violet and fluorescence spectra with those of an authentic sample prepared by zinc dust reduction of 3 : 4-8 : 9-dibenzpyrene-5 : 10-quinone[6].

3 : 4-8 : 9-Dibenzpyrene is a carcinogen of particular interest, not only because it has been detected among the constituents of tar from tobacco smoke[7] but also because it has been shown to possess considerable sarcoma-producing activity in male mice of strain XVII of this Institute, whereas female animals of the same strain are far less susceptible[8].

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A Simple, Rapid Method for Circular Paper Chromatography

I have recently developed in our laboratory the following method for the circular development of a large paper disk which has the advantages of (*a*) rapidity, requiring no more than two and a half hours for a satisfactory separation of sugars and amino-acids, and (*b*) simplicity, as it does not need the various devices of other workers[1,2].

Whatman paper disks 26 cm. in diameter are used. In the centre of the paper a circle 1·5 cm. in diameter is drawn with a pencil. Four to eight cuts, depending upon the number of the samples which will be examined, are made from the periphery up to the centre (Fig. 1). The resulting tips of the triangular areas are bent downward. Each spot is applied on the periphery of the circle, between two adjacent cuts. The solvent is placed in a small vessel which is supported on a glass stand in a glass desiccator 25 cm. in diameter, so that the rim of the vessel is approximately 1 cm. below the rim of the desiccator. Then the tips of the triangular spaces are dipped into the solvent and the desiccator is closed. The front develops as a circle, provided that the desiccator is levelled carefully.

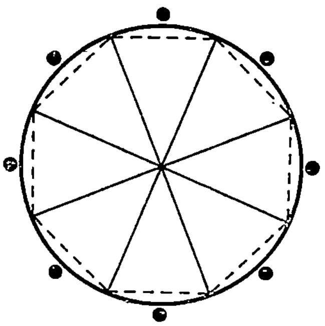

Fig. 1. Diagram showing the cutting and bending of the paper. The solid lines represent the cuts. The broken lines the places where the paper is bent down. The dots represent the spots

Further details of this method will be published elsewhere.

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Configuration of N-acetylneuraminic Acid

Recently, Comb and Roseman[1] observed that N-acetyl-*d*-mannosamine and not N-acetyl-*d*-glucosamine was a substrate for the enzyme synthesizing N-acetylneuraminic acid (nanaldolase) isolated from *Clostridium perfringens*. These results seem to be in conflict with the synthesis of N-acetylneuramic acid from N-acetyl-*d*-glucosamine as reported by Cornforth, Firth and Gottschalk[2]. The observations of Comb and Roseman suggest that N-acetyl-*d*-mannosamine should be the starting product for the synthesis of N-acetylneuraminic acid.

From the reaction mixture of a condensation between N-acetyl-*d*-mannosamine and oxaloacetic acid in aqueous alkaline solution (*p*H 11) at room temperature we isolated an acidic crystalline substance. This acid proved to be identical with N-acetylneuraminic acid isolated from a similar reaction between N-acetyl-*d*-glucosamine and oxaloacetic acid[2]. In both cases the yield was only 1–2 per cent. Variation of the conditions of the reactions and of the relative amount of the reactants did not improve the yield.

Both acids had the same equivalent weight, optical rotation (in water), R_F value (0·13) on Whatman No. 1 paper (descending; butanol/pyridine/water 6 : 4 : 3), intensity of the colour produced with Ehrlich's reagent (measured at 565 mμ), infra-red spectrum in compressed potassium bromide and X-ray powder diffraction pattern (copper K_α). Mr. Boschman of this laboratory found that both substances inhibited influenza virus enzyme to the same degree[3].

The isolation of identical products from the reaction of N-acetyl-*d*-glucosamine and N-acetyl-*d*-mannosamine with oxaloacetic acid appeared to be due to the epimerization of the two amino-sugars under the conditions of the reaction. Aqueous solutions of both amino-sugars (concentration 75 mgm./ml., that is, the same concentration as used in the condensation reaction) were brought to *p*H 11. After standing some time at room temperature the solutions were neutralized with 'Dowex' 50. Samples were run on borate-treated paper with the butanol, pyridine/water (6 : 4 : 3) mixture[4]. Colouring the chromatograms with Ehrlich's reagent after pretreatment with alkali revealed that both solutions contained N-acetyl-*d*-mannosamine as well as N-acetyl-*d*-glucosamine. The epimerization attained equilibrium after 10 hr. as was shown by a determination of the amount of amino-sugar in eluates of the individual spots. At equilibrium the ratio of N-acetyl-*d*-glucosamine to N-acetyl-*d*-mannosamine was 2·2 to 1. After 48 hr., the total amount of amino-sugar was about 75 per cent of the original. Recently, Comb and Roseman[5] have also reported the epimerization of N-acetyl-*d*-glucosamine in aqueous solution at *p*H 11.

These results indicate that the opinion of Cornforth, Firth and Gottschalk[2] that their synthesis confirms Gottschalk's[6] proposal of the configuration of N-acetylneuraminic acid is not wholly justified. Further, we conclude that the isolation of N-acetyl-*d*-glucosamine after an alkaline degradation of N-acetylneuraminic acid as reported by Kuhn and Brossmer[7] and by Zilliken and Glick[8] can be ascribed to the rapid epimerization of N-acetyl-*d*-mannosamine formed originally. This means that the isolation of N-acetyl-*d*-glucosamine can no longer be taken as a proof of the configuration at C_6 of N-acetylneuraminic acid[7]. Our experiments lend support to the results of Comb and Roseman[1]. This implies that the configuration at carbon atoms 5–8 of N-acetylneuraminic acid is the same as the configuration at carbon atoms 2–5 of N-acetyl-*d*-mannosamine.

We are indebted to Mr. A. H. Bierens and Mr. J. Schut for their assistance.

Note added in proof. R. Kuhn and R. Brossmer (*Ann.*, 616, 221; 1958) have re-investigated the degradation of N-acetylneuraminic acid with pyridine and nickel acetate[7]. They now find that N-acetyl-*d*-mannosamine is formed primarily and that this rapidly epimerizes to N-acetyl-*d*-glucosamine.

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3-Ethoxy-4-hydroxybenzoic Acid in Human Urine

In a recent communication[1] an increased excretion of vanillic acid during the stress of motor-rally driving was reported. The 1958 Royal Automobile Club rally offered an opportunity to confirm this finding, and three samples of urine were collected from each of two subjects during the third and fourth days. This was after a considerably longer period of stress than had been experienced in the previous experiment and was determined by the accessibility of the subjects. Acid-hydrolysed urines were examined by the method used previously[2] and both hydrolysed and unhydrolysed urines by a modification of the method of Armstrong *et al.*[3]. In all the samples, vanillic acid was detected only in perfectly normal amount.

However, chromatograms of the final sample from one of the subjects showed the presence in comparatively large quantity, particularly after hydrolysis, of an unusual substance which had previously been detected in four of the ten urines in the first experiment, although in comparable amount in only one of them. Further, reference to chromatograms (prepared some years ago by P. S.) of urines from subjects rendered anoxic by decompression for two hours to a pressure equivalent to an altitude of 14,000 ft. showed that a similar substance had been recorded as present in small amount in six of twenty-three such urines. In thirty-eight normal urines collected over a similar period of time (approximately 9.30–11.30 a.m.) from the same subjects (fifteen normals were duplicated) the compound had been detected only twice. Because no particular attention was paid at the time to this then rather obscure substance the numbers quoted above should be regarded with some reservation, since it is possible that trace amounts might have escaped notice on some chromatograms on which its presence had not been recorded.

The new compound was indistinguishable from vanillic acid in its behaviour towards diazotized sulphanilic acid or *p*-nitroaniline, Folin and Ciocalteu's reagent or 2 : 6-dichloroquinone chloroimide[2], but had higher R_F values in all organic solvents tried. These properties suggested a homologue of vanillic acid, and the substance was readily shown to be excreted following ingestion of ethyl vanillin; it has now proved to be chromatographically identical with 3-ethoxy-4-hydroxybenzoic (ethyl vanillic) acid.

Present evidence suggests ethyl vanillic acid may be detected in normal urines, though rarely in more than trace amounts, rather more frequently than is suggested by the anoxia controls mentioned above, particularly in samples collected at different times of the day. One urine collected after lunch contained the substance in large quantity. Inquiry revealed that the subject in question had, during the previous twenty-four hours, consumed a surprising variety of sweets, but no difficulty was encountered in demonstrating the origin of ethyl vanillic acid to be a well-known confection which evidently contains much ethyl vanillin.

From the two driving-stress experiments, urines were collected from two of the subjects, co-drivers, on five occasions, in each case over similar periods of time. On two occasions nothing of interest was found, but the excretions of vanillic and ethyl vanillic acids in the remaining three pairs of urines are compared in Table 1. The average normal excretion-rate for vanillic acid is about 85 μgm./hr. while ethyl vanillic acid is usually present only in trace amounts. Considerable differences between the subjects in the rates of excretion of at least one of the substances are evident on two of the occasions. Since it is known that these two subjects consumed virtually identical meals throughout, and taking into account our present knowledge of dietary sources of the two compounds, we find it difficult to escape the conclusion that both have an endogenous origin responsible for their increase during stress. The alternative possibility that some substance—which

Table 1. RATES OF EXCRETION OF VANILLIC AND ETHYL VANILLIC ACIDS BY TWO SUBJECTS UNDER STRESS

Substances estimated by visual comparisons of chromatograms from acid-hydrolysed urines with known quantities of authentic material. Spots developed with diazotized sulphanilic acid

Subject and occasion		Vanillic acid (μgm./hr.)	Ethyl vanillic acid (μgm./hr.)
J. B.	1	330	0
A. M. H. B.		420	0
J. B.	2	30	0
A. M. H. B.		330	20
J. B.	3	30	150
A. M. H. B.		30	0

must have been eaten by both subjects—can give sometimes vanillic acid, sometimes ethyl vanillic acid, and on other occasions yield no detectable metabolite, seems rather remote.

It is now clear that any conclusion that vanillic and ethyl vanillic acids are metabolites of adrenaline or other catechol of endogenous origin must await the demonstration that biological ethylation of a catechol hydroxyl group is possible, as an alternative to methylation, in the human subject. Work at present on hand indicates strongly that this is so, but results so far have been insufficiently impressive and too erratic to merit publication at this stage.

We wish to thank the Director-General of Medical Services, Royal Air Force, for permission to publish this work, which will be presented in more detail elsewhere, and Dr. A. M. H. Bennett for his continued co-operation in the collection of urines.

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Purkinje and Ventricular Membrane Resistances during the Rising Phase of the Action Potential

Using double-barrelled micro-electrodes, one barrel for recording the other for passing current, it has been found possible to observe the effects of hyper- and de-polarizing currents on the membrane behaviour of actively beating heart muscle.

An isolated preparation of rabbit right ventricle was driven at a constant rate (approximately 3/sec.) via external electrodes. Purkinje fibres were distinguished by their characteristic action potential and appeared to be localized to the endocardial surface in a sparse network of pale tissue bands similar to those described by Purkinje[1]. Rectangular pulses of current of 100 msec. duration were applied via one barrel of the micro-electrode 80 msec. before the onset of every fourth propagated action potential. Because of the proximity of the two barrels and the relatively high currents required (10^{-8}–10^{-6} amp.) it was not possible to compensate entirely for the artefacts which appeared at the recording electrode, and thus direct determination of the changes in membrane resting potential during the passage of a current pulse was not possible. However, the technique did permit the following measurements to be made: the maximum amplitude of the normal action potential, E_n; the maximum amplitude of the action potential occurring during current flow, E_c; and the applied current, I.

Assuming the current produced no change in membrane behaviour, the following would hold:

$$\frac{dE_c}{dI} = R_r - R_d \qquad (1)$$

where R_r is the polarization resistance in the resting state, R_d is the polarization resistance at the crest of the rising phase and E_c is the difference between the altered resting potential and the potential at the crest of the rising phase. Or, assuming R_r and R_d are constant:

$$E_c = IR_r - IR_d + E_n \qquad (2)$$

Weidmann[2] has shown that in Purkinje fibres of the kid the ratio R_r/R_d is greater than 50, so that the term R_d could be neglected.

A typical relationship between I and E_c in a Purkinje fibre is shown in Fig. 1. There is some variation among these fibres; but all exhibit a curve, straight for values of E_c above 90–100 mV. and curved for lower values. In the former, the slope (dE_c/dI) equals R_r, whereas the steepening in the latter is the result of the additional effect of current on the activity of the sodium-carrying system[3], which, in our experiments, appears maximal at 90–100 mV.

In ventricular fibres, when positive and low negative currents are applied, the slope dE_c/dI varies widely from fibre to fibre. It is generally low and sometimes negative in value. This implies that R_d in equation (1) is of the same order as, and sometimes greater than, R_r. With negative currents greater than a certain value dE_c/dI yields predictable values for R_r 2–3 times smaller than for Purkinje fibres. During this phase R_d is now obviously much smaller than R_r. However, the plot of the amplitude of the action potential 2 msec. after the crest (shown in Fig. 1 by an interrupted line) has a negative slope indicating that the membrane resistance at this time is higher than R_r.

Thus the resistance at the crest of the ventricular action potential is normally of the same order as the resting resistance; whereas in Purkinje fibres the resistance at the crest is much lower, indicating that in ventricular fibres, if there is a sodium-carrying mechanism its activity has normally ceased well before the maximum height of the action potential is reached. This could explain the fact that: (1) the amplitude of the action potential of ventricular fibres (contrary to that of Purkinje) does not decline with reduction in external sodium concentration in the manner predicted by the sodium theory[4-6], and (2) in ventricular

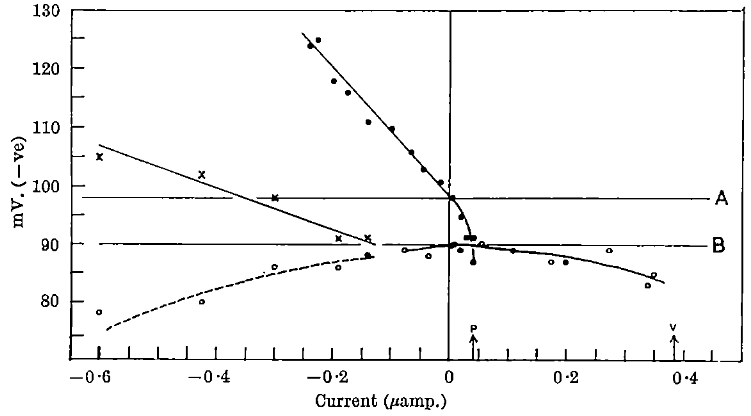

Fig. 1. Effect of current on the amplitudes of Purkinje and ventricular action potentials. Ordinate: action potential amplitude, E_c. Abscissa: current applied via stimulating barrel, +ve; depolarizing: −ve; hyperpolarizing. ●——●, Purkinje action potential; ○——○, ventricular action potential with positive and low negative currents; ×——×, ventricular action potential with high negative current; ○- - -○, ventricular action potential 2 msec. after the crest. *A* and *B* represent the normal amplitudes of Purkinje and ventricular action potentials respectively (that is, in the absence of applied current). *P* and *V* indicate Purkinje and ventricular threshold currents. In this particular experiment the polarization resistances (R_r) of the Purkinje and ventricular fibres were 100 k.ohm and 35 k.ohm respectively

fibres exposed to quinidine the maximum rate of rise of the action potential declines without a concurrent reduction in the amplitude[7].

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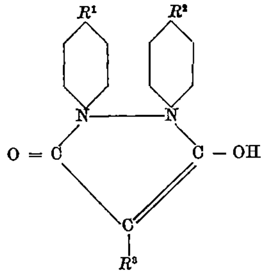
Relationship between pK_a and Uricosuric Activity in Phenylbutazone Analogues

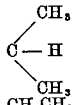
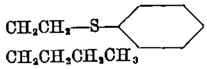
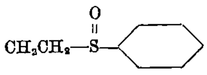
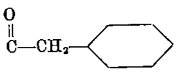
DRUGS which increase the urinary excretion of uric acid are of considerable value in the treatment of gout. Although it is fairly well established that these agents act by interfering with the reabsorption of uric acid by the renal tubular cells, the structural features required for this activity have not been defined. In the course of studies with one such drug, phenylbutazone, a relationship between chemical structure and uricosuric activity was noted. It was found that modifications in phenylbutazone, resulting in increased acidity of the molecule, are associated with enhanced uricosuric activity. However, changes which decrease the acidity of the drug are accompanied by loss of this activity.

In Table 1 are given the pK_a, relative uricosuric activity and biological half-life of a variety of analogues having modifications either in the benzene rings or the butyl side chain of phenylbutazone. The pK_a values were determined in dilute aqueous solutions by a method based on the differences in ultra-violet absorption of the ionized and un-ionized forms of the compounds[1]. The relative uricosuric potency of each compound is expressed in terms of the intravenous dosage required in gouty subjects to elicit a 100 per cent increase in the clearance ratio $C_{\text{uric acid}}/C_{\text{inulin}}$. The biological half-life of each drug was calculated from their rate of disappearance from plasma after single 600–800 mgm. intravenous doses.

In Table 1 the various analogues are arranged in order of increasing acid strength. The *iso*propyl analogue (*G*–13838) and the *p*-dimethyl analogue (*G*–15235), the weakest acids in the series, had no detectable uricosuric effect in intravenous doses of 1,200 mgm. Phenylbutazone and *G*–27202 required 800–1,000 mgm. intravenous doses to elicit a 100 per cent change in uric acid clearance whereas *G*–28231

Table 1. pK_a AND URICOSURIC ACTIVITY OF PHENYLBUTAZONE ANALOGUES



Compound	R^1	R^2	R^3	pKa	Dose of drug for uricosuric effect (mgm.)*	Half-life (hr.)
G–13838	H	H		5·5	No effect with 1,200	72
G–15235	CH_3	CH_3	$CH_2CH_2CH_2CH_3$	4·9	No effect with 1,200	48
G–27202†	OH	H	$CH_2CH_2CH_2CH_3$	4·7	800–1,000	72
Phenylbutazone	H	H	$CH_2CH_2CH_2CH_3$	4·5	800–1,000	72
G–28231†	H	H	$CH_2CH_2\overset{OH}{\overset{\mid}{C}}HCH_3$	4·0	150–300	8
G–25671	H	H		3·9	150–300	3
G–28234	NO_2	H	$CH_2CH_2CH_2CH_3$	3·2	30–100	36
G–28315	H	H		2·8	30–70	3
G-32567	$\overset{O}{\overset{\Vert}{\underset{\underset{O}{\Vert}}{S}}}—CH_3$	$\overset{O}{\overset{\Vert}{\underset{\underset{O}{\Vert}}{S}}}—CH_3$	$CH_2CH_2CH_2CH_3$	2·7	100–150	1
G–30249	OH	H		2·0	30–70	3

* The intravenous dose required to elicit a 100 per cent increase in $C_{\text{uric acid}}/C_{\text{inulin}}$. The compounds were administered to gouty subjects by slow sustained infusion as described previously (refs. 2 and 3).

† *G*–27202 and *G*–28231 are metabolites of phenylbutazone in man (ref. 4).

and *G*–25671 produced this effect in doses ranging from 150 to 300 mgm. However, *G*–28315 and *G*–30249, two of the strongest acids, were active in doses as low as 30 mgm. Further experiments were carried out to determine the maximum uricosuric effect produced by the rapid injection of a single large dose of drug. For example, the rapid injection of 800–1,000 mgm. of either phenylbutazone or *G*–27202 increased the ratio $C_{\text{uric acid}}/C_{\text{inulin}}$ two- to three-fold, whereas the injection of 400 mgm. doses of either *G*–28315 or *G*–28234 increased the clearance ratio seven- to eight-fold. In addition, the oral administration of 800 mgm. doses of phenylbutazone and *G*–27202 produced about a 30 per cent increase in the daily excretion of uric acid over the control values, whereas the same dose of *G*–28315 and *G*–28234 produced about a 125 per cent increase.

The values obtained for the half-life of the various analogues rule out the possibility that the weakly uricosuric analogues may be metabolized or excreted too rapidly to achieve effective plasma levels. The compounds which had the most potent uricosuric effect, such as *G*–28315 and *G*–30249, actually disappeared at a considerably more rapid rate (half-life 3 hr.) than phenylbutazone, *G*–27202, *G*–15235 and *G*–13838 (half-life 2–3 days). The larger dose of *G*–32567 required to produce the uricosuric effect than that needed for *G*–28315 and *G*–28234 may be due to its extremely rapid disappearance (half-life 1 hr.).

The potent uricosuric activity of the highly acidic phenylbutazone analogues indicates that these drugs act in the ionic form to block the reabsorption of uric acid by the renal tubule cells, thus furnishing a possible clue to the still obscure nature of the transport mechanisms involved. The demonstration that uricosuric activity in the phenylbutazone series is related to the pK_a, has proved of considerable aid in searching for new uricosuric drugs. One such drug, *G*–28315, has already been found to be useful clinically as a potent uricosuric agent in treatment of gout[2,5,6].

We are grateful to Dr. Franz Haefliger and his colleagues of Geigy Pharmaceuticals, Basle, Switzerland, for the synthesis of the various phenylbutazone analogues used in this study.

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Decay of Immediate Memory with Age

Current theory tends to emphasize the importance of interference in forgetting and to minimize the role of time lapse in the decay of the memory trace. Conrad[1], however, has recently shown that the immediate recall of eight-digit numbers is better when the numbers are presented and reproduced by subjects at a fast rate than when they are presented and reproduced at a slow rate. He interprets this finding as indicating that simple decay of the memory trace is an important factor in the loss of immediate memory.

In the course of a more complex investigation of the relation between age and ability to retain for short- and long-term periods various classes of material, I tested two groups of subjects for their ability to retain eight-digit numbers when presented and reproduced at different rates. Group *A* consisted of 26 teachers, aged 18–29, drawn from different regions of Canada. Group *B* consisted of 26 teachers, aged 30–55, also drawn from different regions of Canada, and matched as closely as possible with Group *A* in general background, marks on university summer-school courses, and tests of remembering.

The results confirmed Conrad's finding that immediate recall is better when the numbers are presented and reproduced by subjects at a fast rate (120 digits per min.) than when they are presented and reproduced at a slow rate (40 digits per min.). The mean fraction of digits recalled at the slow rate was 0·475, and at the fast rate 0·543. These scores are both better than those reported by Conrad, but the samples in the present experiment are probably drawn from populations of higher intelligence, and the rates of presentation are slightly faster than in Conrad's experiment, both factors being likely to improve the scores on an immediate memory task.

Analysis of the results shows that there is no significant difference between the two groups in the proportion of digits recalled at the fast rate, but that there is a significant difference between the two groups ($P = 0{\cdot}05$) in the proportion of digits recalled at the slower rate. The actual figures are given in Table 1.

Table 1

Group	Proportion of digits recalled	
	Slow rate	Fast rate
A	0·51	0·575
B	0·37	0·58

If Conrad's technique is an adequate measure of the decay factor in immediate memory, and if the present finding is confirmed by further research, it appears that the span of immediate memory is the same for the two age groups, but that the rate of decay of immediate memory tends to increase with age.

This study was carried out while I was in receipt of a grant from the Department of Veterans' Affairs, Ottawa. Full details of the completed study will be published elsewhere. My thanks are due to Dr. J. M. Blackburn for his interest and encouragement.

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Comparison of the Tendency to cling to Glass and Hæmagglutination produced in Erythrocyte Suspensions by Ferric Chloride and by Influenza Virus

In a recent publication[1] dealing with the mechanism of virus hæmagglutination, it was suggested that erythrocytes that had adsorbed the virus became hydrophobic, hence their tendency to cling to glass. This hydrophobic character of the virus – erythrocyte adsorption complex produces behaviour similar to that observed with oil droplets in an aqueous medium. That is, under the influence of surface tension the complex adheres to any surface with which it is in contact. It was further suggested that the aggregation of erythrocytes (hæmagglutination), as well as tendency to cling to glass (shield formation), could be explained in this fashion without the necessity of postulating virus 'bridges'[2] linking cell to cell and cell to glass.

Some further studies have been performed by treating the erythrocytes with ferric chloride and comparing the ability of these cells to cling to glass beads with the similar ability of cells treated with virus or virus plus a cationic surfactant. The addition of a cationic surfactant enhances the ability of virus to produce the tendency to cling to glass.

The treatment with ferric chloride involved diluting a solution of 0·5 *M* $FeCl_3.6H_2O$ containing 20·0 ml. of concentrated hydrochloric acid per litre with isotonic saline, just prior to use, to yield a concentration of 100 µgm./ml. Ferric chloride prepared in this manner yields no colour when treated with *o*-phenanthroline and gives an opalescent solution the opalescence of which gradually increases. Both facts suggest that a colloidal suspension, or a suspensoid, rather than a solution is produced.

With both ferric chloride and virus, the erythrocytes and the respective agglutinin were mixed to yield a final volume of 5·0 ml. Changes in optical density of the mixture at 540 mµ were followed and when no further changes were observed, or at least 15 min. had elapsed, 50·0 mgm. of glass beads with a mean diameter of 60µ were added. Before use these beads were washed in acid and repeatedly rinsed with distilled water. After addition of the beads, the tubes were inverted several times, the beads allowed to settle, and the optical density of the erythrocyte suspension was determined. This was repeated until the optical density remained constant. When erythrocyte suspensions without added agglutinin are treated in this fashion no change in optical density occurs when the glass beads are added; nor is any change observed when the erythrocyte suspension contains virus or virus plus 4 µgm./ml. of cationic surfactant. The results obtained when ferric chloride is added are presented in Fig. 1. In this case the erythrocytes cling to the beads and are carried down with them. In addition, a more drastic hæmagglutination is produced by the ferric chloride.

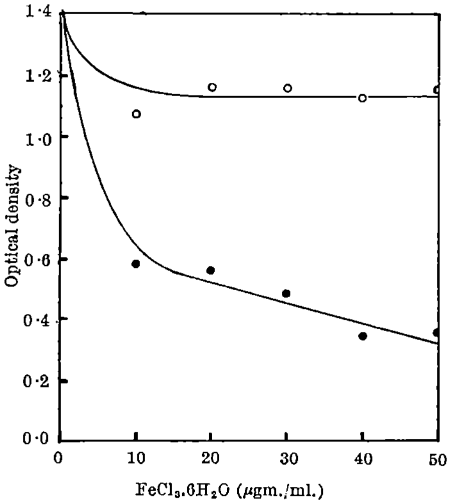

Fig. 1. Effect of concentration of ferric chloride upon the stability of a suspension of human erythrocytes in the presence or absence of glass beads. ○—○, Samples before adsorption with glass beads; ●—●, samples after adsorption with glass beads

These observations suggest that the forces responsible for virus hæmagglutination and the tendency to cling to glass are considerably weaker than those operating when ferric chloride is the agglutinin. In the latter case these forces would presumably be chemical bonding forces, or electrostatic interactions, or both. Thus, the observations are consistent with the postulate that surface tension, rather than virus 'bridges', underlies hæmagglutination and 'glass cling' of the virus – erythrocyte combination. Further support for this contention can be drawn from the study of electrostatic effects in virus hæmagglutination reported by Shingu[3].

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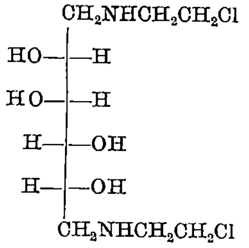
Tumour-inhibiting Action of 1 : 6-Dimethanesulphonyl-D-mannitol

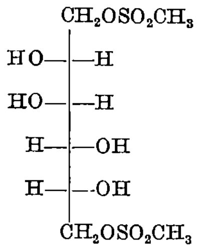
Extensive clinical experience with 'Myleran' (I, $n = 4$) in the treatment of chronic myeloid leukæmia[1] has shown that when over-dosage is avoided the drug is free from side-effects. On the other hand, other alkylating agents which are used clinically, namely, ethyleneimine derivatives and nitrogen mustards, usually cause some side-effects. This contrast may be attributable to a different mechanism of action for 'Myleran' and for the other alkylating agents. Evidence for this difference arises from comparison of the effects of 'Myleran' and a mustard (chlorambucil) on rat bone-marrow[2] and from a similar comparison where, when the drugs were used clinically in leukæmia, there was no enhanced excretion of uric acid after administration of 'Myleran' although nitrogen mustards and triethylenemelamine caused a significant rise in uric acid excretion[3]. 'Myleran' and its congeners (I), while they inhibit experimental tumours, cause a marked depression of bone-marrow function and cannot therefore be considered suitable for the treatment of solid tumours in man. In the 'Myleran' series there is evidence that variations in neutrophil-depressing and also in tumour-inhibitory activity may depend very much on the ratio between the solubility of the particular compound in water and in ether[4]. In the hope that a very large relative increase in water solubility might possibly minimize the bone-marrow depressing properties of the 'Myleran' series while leaving unaffected tumour-inhibitory activity together with the apparent clinical virtues attributable to the 'Myleran' type of action, we decided to modify the series by the insertion of hydroxy groups in the polymethylene chain. *Bis*-1:6-2′-chloroethylamino-1:6-dideoxy-D-mannitol (II) had been made because it was a type of nitrogen mustard which it was thought might inhibit glycolysis[5]. The fact that its tetrahydroxylated hexamethylene chain structure was consistent with tumour-inhibiting activity led us to choose 1 : 6-dimethanesulphonyl-D-mannitol (III) as the first member of our new series.

$CH_3SO_2O(CH_2)_nOSO_2CH_3$

(I)



(II)



(III)

1 : 6-Dimethanesulphonyl-D-mannitol was first prepared by the reaction of 1 : 2-5 : 6-dianhydro-3 : 4-*iso*propylidene-D-mannitol with methanesulphonic acid, in ether solution. As we expected, the two epoxide rings were split and addition of 2 mol. of methane sulphonic acid occurred, but the *iso*propylidene residue then evidently became highly labile and was lost by hydrolytic splitting in the presence of a trace of water taken up by the ether in the course of the experiment. The structure assigned was unequivocally shown to be correct by synthesis via benzylidenation of 1 : 6-dibenzoyl-D-mannitol, followed by debenzoylation, mesylation, acetolysis and methanolysis.

Under biological test, 1 : 6-dimethanesulphonyl-D-mannitol combines relatively low toxicity with powerful inhibition of the growth of the Walker rat carcinoma-256, and of a radiation-induced rat lymphatic leukæmia. Substantial inhibition has also been observed in the case of the exceptionally resistant 'August' rat carcinoma.

The investigation has been supported by grants to this Institute from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

Note added in proof. Since submitting this communication, we have simplified the preparation of the drug by showing that successive treatment of D-mannitol with 2 mol. of methanesulphonyl chloride and 4 mol. of acetic anhydride in pyridine solution yields its tetracetyl derivative.

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Forssman's Antigen in Ehrlich Mouse Carcinoma

THE question of whether a specific antigen exists in cancer tissue is receiving increasing attention. The view generally held is that carcinoma contains Forssman's[1] antigen.

Injection of rabbits with a cell suspension prepared from transplantable Ehrlich's mouse carcinoma gives rise to the formation of heterogenetic Forssman antibodies[2]. But two forms are known of Ehrlich's carcinoma ; (*a*) the solid tumour formed after subcutaneous inoculation, and (*b*) the ascites tumour seen after intraperitoneal injection.

Our investigation was made with the 'classic' Ehrlich transplantable tumour strain, which was placed at our disposal by Dr. Eva Melander, Institute of Genetics, University of Lund, Sweden.

By immunizing rabbits with cell suspensions of solid Ehrlich carcinoma we had no trouble in confirming Morgenroth's[2] statement ; but with the ascites carcinoma we could not reproduce his findings ; Forssman's antibodies could not be induced by injecting rabbits either with cells and liquid withdrawn from the peritoneal cavity of inoculated mice, or with cells or liquid separated by centrifuging.

The action of rabbits' sera was judged by their power to lake 5 per cent suspensions of sheeps' red blood corpuscles in the presence of complement. Examples of several tests, all with similar results, are shown in Table 1.

Table 1

Rabbit's serum	Hæmolytic titre	
	Before immunization	After immunization
Anti-Ehrlich carcinoma	1 : 100	1 : 4000
,,	1 : 10	1 : 2000
,,	1 : 10	1 : 1000
Anti-ascites carcinoma	1 : 50	1 : 100
,,	1 : 200	1 : 100
,,	1 : 50	1 : 50
Anti-ascites carcinoma cells	1 : 100	1 : 100
,,	1 : 50	1 : 20
,,	1 : 20	1 : 50
Anti-ascites carcinoma liquid	1 : 200	1 : 200
,,	1 : 100	1 : 50
,,	1 : 100	1 : 100

These results make one doubt whether Forssman's antigen is, in fact, a component of the Ehrlich mouse cancer cells at all. But this was confirmed by the following experiments.

Sera with known heterogenetic antibody content (anti-guinea pig kidney serum, and anti-sheep red-cell serum) were absorbed with either Ehrlich carcinoma or ascites carcinoma cells. Ehrlich carcinoma cells invariably suppressed the hæmolytic titres of these anti-Forssman sera. Ascites carcinoma cells, on the other hand, failed to do so.

Alcoholic extracts of both types of cell suspension were then prepared. Those of the Ehrlich carcinoma cells produced clear-cut ring reactions with the anti-Forssman sera when tested by Sachs and Guth's method[3]. Alcoholic extracts of the ascites carcinoma-cells invariably failed to react.

Ascites carcinoma, unlike Ehrlich carcinoma, appears to be free of heterophilic antigen. This seems surprising : (*a*) because the mouse is a Forssman's antigen-bearing animal, and (*b*) in view of the generally held opinion that cancers contain heterophilic antigen, even in Forssman-negative species.

Further consideration, however, shows that the histological structure of the two carcinomas differs in that Ehrlich carcinoma is rich in fibroblasts and capillaries; it has a rich stroma of mesodermic origin. Ascites carcinoma, on the other hand, consists of epithelial carcinoma cells with no other component except the peritoneal fluid suspending the cells. This certainly suggests that it is the stroma part of the solid tumour, and not the carcinoma cells as such that carries the heterophile antigen. This supposition finds support in a paper by Tanaka and Leduc[5], in which they state that Forssman's antigen in various normal organs of Forssman-positive species (guinea pig, mouse) is present mainly in the connective-tissue structures, and not in the parenchyma; it was located microscopically by the fluorescent antibody method. Although no similar data are as yet available concerning cancer tissues, this may prove to be correlated with our own findings. It should be possible to confirm this by the same technique[6].

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Differences between the Early Metabolic Effects of Thyrotropic Hormone and Triiodothyronine

The physiological significance of triiodothyronine is still uncertain[1]. In previous reports[2] [3] rapid metabolic changes, possibly of thyroid origin, have been described in association with emotionally stressful life experiences in man. An investigation was therefore undertaken to see how soon metabolic changes could be demonstrated following triiodothyronine and thyrotropic hormone.

Observations on metabolic rate, pulse-rate, blood pressure and various urinary constituents were made at 2-hr. intervals for a period of 8 hr. in five healthy volunteer medical students following triiodothyronine (kindly supplied by Glaxo Laboratories) (0·5 or 1 mgm.) given intravenously as a single injection, and thyrotropic hormone ('Thytropar', kindly supplied by Armour and Co., Chicago) (0·44 U.S.P. units/kgm. body-weight) given intramuscularly. As a control observations were made following the intramuscular injection of saline. All studies were made in the fasting state using techniques previously described[4].

The rise in metabolic rate was greater with thyrotropic hormone than with triiodothyronine ($P < 0\cdot01$). The elevation with triiodothyronine was barely significant within this time ($P = 0\cdot07$) (Table 1).

Table 1. Mean Effect of Thyrotropic Hormone and Triiodothyronine on Metabolic Rate (cal./sq.m./hr.)

Treatment	Time (hr.) 1	3	5	7
Saline	39·5	39·9	41·3	42·3
Triiodothyronine	38·9	40·7	42·1	43·7
Thyrotropic hormone	38·0	40·8	44·2	46·2

The associated elevation of pulse-rate with thyrotropic hormone was significantly greater than with triiodothyronine ($P < 0\cdot01$) which did not differ from the control; elevation of pulse pressure was also observed following thyrotropic hormone but not following triiodothyronine. Significant elevation of serum protein-bound iodine has been previously noted within 4 hr. following thyrotropic hormone in similar dosage[5].

However, triiodothyronine produced a greater increase in inorganic phosphate excretion ($P < 0\cdot025$), similar to that previously described[4], indicating a different metabolic effect from that of thyrotropic hormone (Table 2).

Table 2. Mean Effect of Thyrotropic Hormone and Triiodothyronine on Inorganic Phosphate Excretion (mgm./min.)

Treatment	Time (hr.) 0–2	2–4	4–6	6–8
Saline	0·39	0·47	0·53	0·53
Triiodothyronine	0·46	0·46	0·80	1·04
Thyrotropic hormone	0·37	0·49	0·55	0·47

Transient increases in sodium and potassium excretion within the first 4 hr. were noted following thyrotropic hormone ($P < 0\cdot05$) but not following triiodothyronine.

The specificity of these changes following thyrotropic hormone was confirmed when it was given in similar dosage to a series of five hypothyroid subjects on maintenance dosage of desiccated thyroid (Table 3).

Table 3. Mean Effect of Thyrotropic Hormone on Metabolic Rate in Five Hypothyroid Subjects on Thyroid (cal./sq.m./hr.)

Treatment	Time (hr.) 1	3	5	7
Saline	34·4	33·6	35·1	36·3
Thyrotropic hormone	34·1	34·2	36·0	36·9

The effect of thyrotropic hormone on the metabolic rate was significantly less than in the normal subjects ($P < 0\cdot001$); the rise in pulse-rate was also less ($P = 0\cdot07$); no increase in sodium and potassium excretion occurred. The mean increase in metabolic rate was proportionately greater in the normal subjects (21·6 per cent) than in the hypothyroids (8·3 per cent).

These findings suggest that the early effect of thyrotropic hormone differs from that of triiodothyronine but is still of thyroid origin. They support previous suggestive evidence obtained from observations made during emotionally stressful life experiences in man[2] [3] of a rapidly active thyroid hormone distinct from triiodothyronine.

In this connexion it is of interest that the calorigenic effect of desiccated thyroid is greater than that indicated by its 'thyroxine iodine content'[6]. Similar findings have been reported with thyroglobulin[7,8]. Such discrepancies appear to be too great to be accounted for by the minute amounts of triiodothyronine recovered from the thyroid[9].

In a recent chromatographic study no increase in triiodothyronine could be demonstrated in the plasma following thyrotropic hormone in euthyroid subjects[10].

The observations reported here indicate that the early metabolic effect of the thyroid secretion under stimulation by thyrotropic hormone is not accounted for by triiodothyronine. They provide evidence of a rapidly active thyroid hormone distinct from triiodothyronine as previously suggested[5].

Further investigations are in progress and more detailed findings will be published elsewhere.

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An Anticlumping Factor for Mitochondria in the Supernatant Fraction of Rat-Liver Homogenates

In a rat-liver homogenate that has not been strongly diluted the mitochondria remain substantially unclumped for several hours even at room temperature; but if it is diluted more than about five-fold with a medium containing electrolyte, serious clumping may occur in a few minutes. If it is diluted with the supernatant from another homogenate which has been only slightly diluted, clumping is almost completely inhibited. This shows that a natural anticlumping factor is present in the supernatant. The factor is thermolabile, non-dialysable and precipitable from supernatant by half-saturated ammonium sulphate. Its activity is lost gradually at 0° C. but is retained indefinitely at − 15° C. The lability suggests that it is not identical with heparin, which is known to prevent mitochondrial clumping. This is confirmed by the fact that our factor does not, like heparin, produce nuclear haloes[1] by combining with histone and liberating deoxyribonucleic acid. On the other hand, all its properties known so far correspond with those of the ribonuclease inhibitor discovered by Roth[2,3], which is also not identical with heparin although the latter inhibits ribonuclease. We therefore tested crystalline pancreatic ribonuclease for clumping activity and found it very potent in absence but not in presence of supernatant, as expected. Thus there is good reason for accepting as a working hypothesis that our anticlumping factor and Roth's ribonuclease inhibitor are identical, though this can be established with certainty only by isolation of the two substances. Our factor, like Roth's, varies greatly in concentration in apparently similar preparations. One supernatant had perceptible anticlumping activity at a dilution of 1/180, suggesting that even crude concentrates of the factor will be useful protectors in any experiments where mitochondria need to be kept in good condition.

The quantitative assessment of mitochondrial clumping is not easy. We tried various indices, for example the ratio of total clumps (including single mitochondria) to total mitochondria, or the number of mitochondria in the largest clump in a field. Finally, we made a scale consisting of nine numbered photographs of mitochondria clumped by incubation with ribonuclease for varying times, and chosen so that the general impression of clumping in adjacent photographs was just perceptibly different (Fig. 1). Other photographs were then assigned 'clumping numbers' from 0 to 8 by matching against the standards. This principle, whereby the scale unit is defined in terms of the unit of subjective discrimination, is the basis of the well-known Munsell colour scale[4] and was used by Bourdillon and his co-workers[5] in assessing rickets in rats.

A rough test of accuracy was performed by asking eleven judges, separately, to place the nine standard photographs in order. Comparing their rankings with the expected order, it was found that no judge displaced the rank of any photograph by more than ± 2 units and that such displacements occurred in only three of the 99 cases. The greatest mean displacement of a photograph, averaging over the eleven judges, was 0·36 unit. The distribution of the 99 displacements was [see over]:

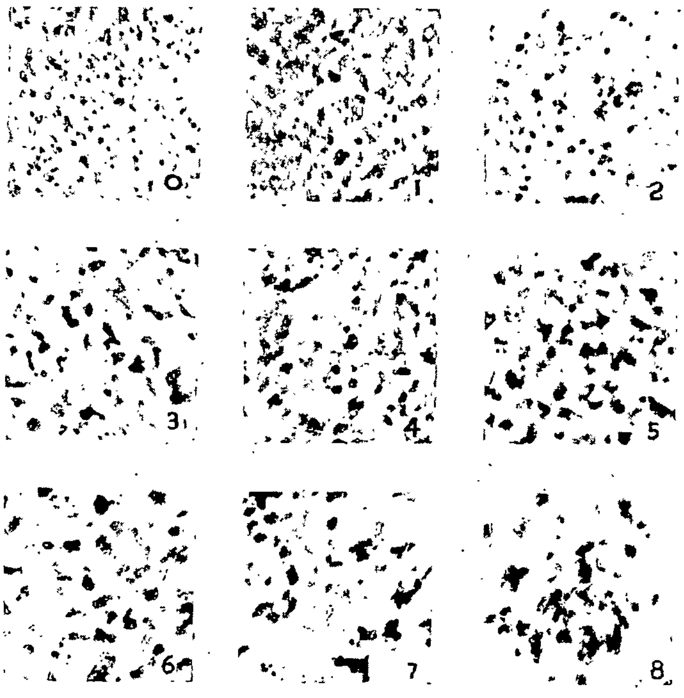

Fig. 1. Photographic scale for assessment of mitochondrial 'clumping number'

Displacement units	−2	−1	0	+1	+2
Frequency	1	13	72	11	2

The distribution is leptokurtic. The root-mean-square displacement is 0·6 unit. The coefficient of concordance[6] is 0·95 and is highly significant. Thus there is a marked measure of agreement between the rankings of the eleven judges, and their average judgment agrees with the expected order. The use of clumping numbers to demonstrate the clumping action of ribonuclease and the anti-clumping action of liver supernatant is shown in Fig. 2. The amount of supernatant used in this experiment gave 98 per cent inhibition of the breakdown of added ribonucleic acid by the same amount of ribonuclease.

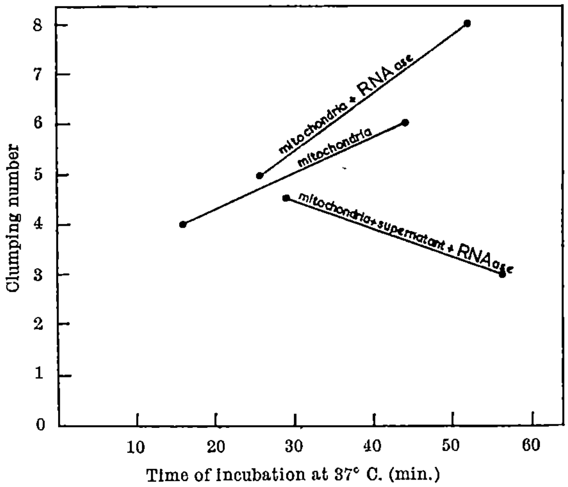

Fig. 2. Enhancement of clumping of mitochondria by added ribonuclease, and protection by supernatant. The mitochondria were washed with and suspended in 0·3 M sucrose, 0·1 M sodium chloride, 0·01 M potassium phosphate pH 7·8, with the addition of 0·005 γ/ml. crystalline pancreatic ribonuclease (top line) or 0·005 γ/ml. ribonuclease + liver supernatant at a dilution of 1/180 (bottom line)

If mitochondrial clumping is commonly due to the action of endogenous ribonuclease, the fact that it is promoted by electrolytes in general, which are known to activate ribonuclease[7], is readily explained. In addition, however, the divalent cations Ca^{2+} and Mg^{2+} seem to have a clumping action out of proportion to their effects on ribonuclease. This action seems to be partly reversible by chelating agents such as ethylenediamine tetraacetic acid, and by dialysed half-saturated ammonium sulphate fraction of supernatant. We therefore tested the latter for calcium chelating power colorimetrically with ammonium purpurate. Although the technique was imperfect it sufficed to show that the calcium-binding capacity of the anti-clumping fraction of supernatant per atom of nitrogen is about five times greater than that of whole supernatant. Thus the anti-clumping fraction may protect mitochondria by reversing the action of calcium as well as by preventing the action of ribonuclease. The two phenomena can be explained simultaneously by supposing that mitochondria are kept apart by negatively charged phosphate groups of ribonucleic acid, and that these charges can be abolished either reversibly by combination with calcium ions or irreversibly by hydrolysis of the ribonucleic acid. Although there is not much ribonucleic acid in mitochondria there is probably enough to satisfy this hypothesis, provided that it is mainly at the surface.

We wish to thank Miss S. Gibbons for assistance and Mr. D. R. Westgarth for statistical advice.

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Hyperglycæmia induced in Rabbits by 5-Hydroxytryptophan

Administration of large doses of 5-hydroxytryptophan (60–100 mgm./kgm.) to rabbits produces marked central effects, for example, mydriasis, hyperpnœa, tachycardia, tremor and ataxia[1,2]. These effects seemed to be similar to those observed after giving lysergic acid diethylamide[1]. As lysergic acid diethylamide very markedly raises the blood-sugar level in the rabbit by a central action[3,4], 5-hydroxytryptophan should also produce hyperglycæmia if its central effect is similar to that of lysergic acid diethylamide.

Blood-sugar measurements were made using the modified method of Shaffer and Hartmann[5] in the blood of the ear artery of rabbits. It was found that 5-hydroxytryptophan given intravenously in small doses (5–20 mgm./kgm.) definitely raised the blood-sugar level. Fig. 1 shows the blood-sugar rise after 10 mgm./kgm.; Fig. 2 shows the dose–response curve, plotted on a logarithmic scale.

5-Hydroxytryptophan had to be given in doses at least 200 times higher than those of lysergic acid diethylamide to produce a comparable hyperglycæmic effect. 5-Hydroxytryptophan was also much weaker than lysergic acid diethylamide in producing a rise in body temperature (see ref. 6). Unlike lysergic acid diethylamide, however, 5-hydroxytryptophan elicited a hyperglycæmic effect when smaller doses were given than those required to produce an increase in body temperature[6].

During aprobarbital anæsthesia it was not possible to elicit hyperglycæmia with 5-hydroxytryptophan (20 mgm./kgm.). This suggests a central effect as

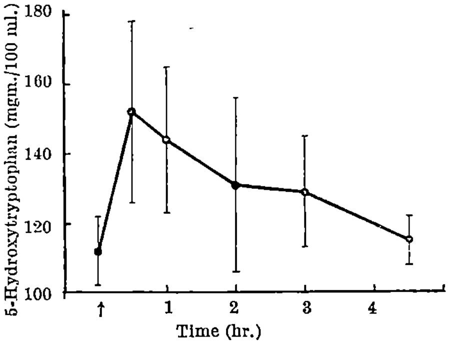

Fig. 1. Hyperglycæmic action of 10 mgm./kgm. 5-hydroxytryptophan (given intravenously at †). The vertical lines indicate the standard deviation of results obtained from nine animals ($P < 0·001$ for the highest value)

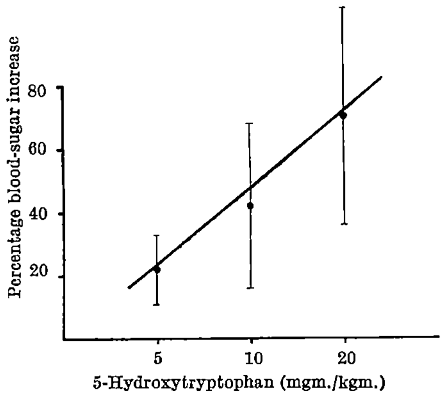

Fig. 2. Dose response curve for the hyperglycæmic action of 5-hydroxytryptophan administered intravenously. The mean response to 5 and 10 mgm./kgm. was established in nine animals, to 20 mgm./kgm. in six. The vertical lines indicate the standard deviation of results. Statistical calculation showed that the regression line did not depart significantly from linearity

in the case of lysergic acid diethylamide, whereas the blood sugar increase due to the peripheral action of adrenaline does occur under aprobarbital.

The hyperglycæmic effect of 5-hydroxytryptophan, which is the precursor of 5-hydroxytryptamine, may be of interest since 5-hydroxytryptamine can, under certain conditions (depancreatized dogs), produce a rise in blood sugar[7] and since the pancreas exhibits a high degree of 5-hydroxytryptophan-decarboxylase and mono-amino oxidase activity[8].

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Lathyrism in Mice

IT is known that rats fed on a diet containing 50 per cent sweet-pea (*Lathyrus odoratus*) seed develop severe bony deformities, and that if young animals are used a proportion die of rupture of the aorta[1,2]; β-amino-propionitrile has a similar effect[3]. Few workers had previously attempted to produce lathyrism in mice, and their reports suggested that mice were refractory. Preliminary experiments, however, showed that aortic lesions in mice could be obtained, and while this work was in progress Dasler and Milliser[4] reported the production of aortic lesions in male weanling mice by feeding them on *L. odoratus* seeds; injection of high doses of β-amino-propionitrile gave, in addition, bony lesions. Experiments were continued with the aim either of confirming Dasler and Milliser's work and producing lathyrism in a cheap and easily handled animal or, if the mouse were resistant, of using this difference in response between two such closely related species as the rat and the mouse for investigation of the pathogenesis of lathyrism.

Porton mice were used, and either fed on a diet containing sweet-pea seed or injected with β-amino-propionitrile. The diet consisted of 40–50 per cent *Lathyrus odoratus* seed, finely ground, mixed with ground rat-cake (diet 86) and reconstituted into cubes with water; β-amino-propionitrile was given as the hydrochloride by subcutaneous injection of a 1 : 10 solution in distilled water; dosage was approximately 0·1 ml./10 gm. body-weight.

In all 200 mice were treated. In 152 treatment started either *in utero* or in the suckling period. Thirty mice from various litters were eaten or unfit for histology; in addition, four entire litters of mothers treated during pregnancy were destroyed by the mothers, and are not included. Forty-five mice which either died or were killed before the age of two weeks were examined: all had histological lesions of the aorta, and approximately half had aortic rupture. In 77 mice, treatment was continued either *per os* or by injection for a varying period after weaning: in 53 aortic lesions were present. Thirty-three mice started treatment when between 2 and 5 weeks of age (injected or weaned on to the sweet-pea diet): seventeen had histological lesions. Fifteen mice started treatment when more than 8 months old: none had significant lesions.

The aortic lesions can conveniently be divided into two main groups. In all infant mice treated *in utero* or in the first few days of life by feeding or injecting the mother there is a characteristic change in the elastica, which is thinned and often interrupted. A proportion of the young die—some of aortic rupture. These experiments show clearly that the toxic principle passes the placenta and is also excreted in the milk.

In the older mice, thinning of the elastica is not observed. Instead, there is rupture of elastic laminæ ranging in severity from rupture of individual laminæ to total rupture of the aorta. Rupture of individual laminæ is occasionally seen in untreated old mice, but not in young animals.

As in rats, aortic lesions are produced only in young animals, though the dosage required to produce aortic lesions in mice is higher. The period of maximum susceptibility was found to extend from the last week of intra-uterine life to the fifth week of post-natal life. Within these limits the younger the animal the easier it is to produce lesions. If treatment is given to the mother during the first two weeks of pregnancy and then stopped, the young are born healthy, though histologically the elastica is abnormal, particularly the outer layers, which are thinned. Treatment started after 5 weeks of age has no effect.

A difference in the susceptibility of the sexes has not been reported in rats, whereas in mice sex markedly affects results. When treatment is given *in utero* or in the first few days of life, both sexes are affected. However, if started at 2 weeks of age or later, aortic damage occurs predominantly in the male. It is noteworthy that Dasler and Milliser[4] used only male mice, and it seems probable that had they used mice of both sexes they would have produced fewer aortic lesions. Again, in contrast with the rat, mice do not develop bony lesions with the dosage I have used.

Menzies and Mills[5] suggested that in rats the primary lesion is in the ground substance, and that proliferation of fibroblasts precedes elastic damage. The histology in mice shows clearly that, in infant mice at least, there is an alteration in the elastica before any increase in ground substance can be recognized. Also, in sections from adult mice, rupture of elastic fibres is frequently seen in the absence of any fibroblastic proliferation. Lastly, no alteration in the muscle cells is apparent in any of the sections. This leaves the elastica as the element primarily affected.

The fact that the period of susceptibility coincides with the period of maximum growth suggests that the condition is not one of degeneration of the elastica but rather of malformation.

My thanks are due to Dr. G. W. Crosbie of the Biochemistry Department, University of Glasgow, for preparing the β-amino-propionitrile.

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Day-length and Hæmatin Compounds in Plants

IT has been shown that day-length regulates the chlorophyll content of many plants[1-3] and that this is a true photoperiodic phenomenon[4]. In leguminous plants, day-length controls both the chlorophyll content and the number and efficiency of the root nodules[5,6]. It seems that, in this case, both the synthesis of hæmoglobin in the nodules and the synthesis of chlorophyll in the leaves are depressed by short day-length. Moreover, there are indications that in some plants (tobacco, for example), the ratio between the quantity of chlorophyll and the quantity of total hæmatin in the leaves remains constant over a wide range of concentrations (Davenport, H., personal communication).

I therefore thought it of interest to investigate whether day-length influences hæmatin-content as it does chlorophyll-content. I studied simultaneously the chlorophyll and total hæmatin during long-day (16 hr.) and short-day (8 hr.) in four species: soya bean (*Soja hispida*), lupin (*Lupinus albus*), wild strawberry (*Fragaria vesca*), and hemp (*Cannabis sativa*). Total hæmatin was measured by the method of Hill and Scarisbrick[7]. Chlorophyll was measured with the Beckman spectrophotometer in 80 per cent acetone using the formula of Mackinney[8].

As shown in Fig 1, in mature leaves there was generally a constant molar ratio of about 60 molecules of chlorophyll to 1 molecule of hæmatin.

In the leguminous plants, soya bean and lupin, the ratio remains constant on changing from long to short days and vice versa. Short-day treatment reduces the hæmatin- and chlorophyll-content of the leaves simultaneously and to the same extent, while long-day treatment increases both. In the leaves, there is about 20–30 per cent less hæmatin during short-day than during long-day (Table 1). The decrease is not only evident in the leaves, but also in the roots. With the lupin, some nodules during short-day had a hæmatin-content 50 per cent lower than in the long-day control. These facts support the idea that, in the leguminous plants, the lack of nodule formation and efficiency in short-day is due to a general hæmatin deficiency, itself related to a marked depression of chlorophyll content in short-day. The occurrence of such a relation between hæmatin and chlorophyll is particularly striking when one considers the photoperiodic control of flowering.

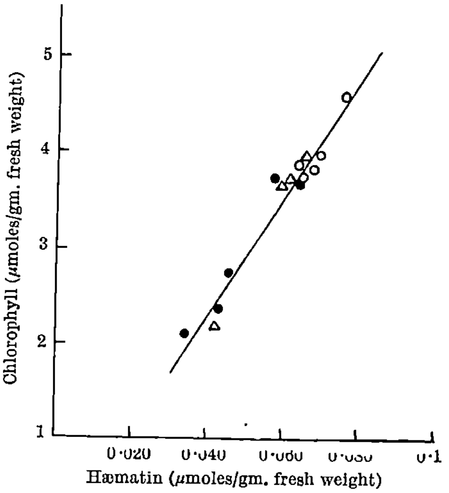

Fig. 1. Relation between hæmatin- and chlorophyll-content in mature leaves. (For lupin and soya bean, the different chlorophyll contents were obtained in different day-length conditions; for hemp, the figures are for long-day only.) ●, lupin; ○, hemp; △, soya bean

In wild strawberry, which does not flower when grown in short-day, we find a much lower hæmatin-content in the mature leaves in short-day than in long-day (in agreement with the decrease in chlorophyll content). But the opposite occurs in hemp, a plant in which flowering is immediately induced by short-day. A typical experiment is shown in Fig. 2. In long-day, hemp shows the normal molar ratio chlorophyll/hæmatin of about 60. If one transfers it at the stage of four expanded leaves from long- to short-day, the chlorophyll content immediately decreases[2]. In this particular case, however, instead of decreasing, the hæmatin content increases (the molar ratio chlorophyll/hæmatin drops to 30–40). In short-day, there is about 30 per cent more hæmatin than in long-day. The transformation is very rapid. It needs only five short days to show a significant effect in the fourth leaf. It is entirely reversible. After five short days, the transfer back to long-day leads to an increase of chlorophyll content and a decrease of hæmatin. The molar ratio chlorophyll to hæmatin returns to its normal value of 60. At the same time, induction of flowering stops.

Table 1. EFFECT OF DAY-LENGTH ON HÆMATIN CONTENT IN LUPIN AND SOYA BEAN
Hæmatin in µmoles/gm. fresh weight

Organs analysed	Day-length	Lupin			Soya bean	
		Series No.			Series No.	
		1	2	3	1	2
Adult leaves (*a*)	Long	0·058	0·046	0·065	0·060	0·066
	Short	0·043	0·035	0·037	0·046	0·043
Roots (*b*)	Long	0·017	0·014	0·011	0·016	—
	Short	0·012	0·010	0·007	0·008	—
Nodules	Long	0·270	0·144	—	—	—
	Short	0·124	0·083	—	—	—

(*a*) The following leaves have been analysed: in lupin, leaf No. 12 (series 1 and 2) and leaf No. 14 (series 3); in soya bean, leaf No. 1 (series 1) and leaf No. 2 (series 2).

(*b*) In lupin, the principal roots have been analysed; in soya bean the total roots including the secondary roots.

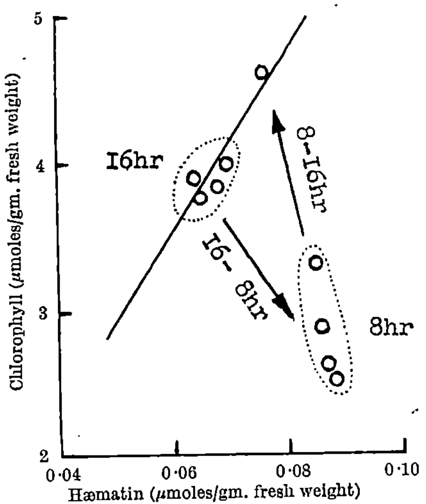

Fig. 2. Effect of transfer from long to short days and vice versa on chlorophyll/hæmatin ratio in hemp. (The arrows indicate directions of transfer; see text)

Further details of these experiments will be published elsewhere. I am greatly indebted to Dr. R. Hill for valuable help in the method of measuring hæmatin in leaves, to Prof. F. G. Young for providing facilities in the Department of Biochemistry, Cambridge, to Mr. J. Gilmour, director of the Botanical Garden, Cambridge, for growing the plants, and to the I.R.S.I.A. (Belgium) for financial support.

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Occurrence of Coumarin Analogues in Lemon Juice

THERE has been little or no investigation of coumarin compounds in lemon juice although their presence in lemon oil has been well established[1–4].

It was of interest to determine whether coumarin analogues were indeed present in lemon juice. Petroleum ether extracts of California lemon juice concentrates were examined by the chromatostrip technique of Miller and Kirchner[5]. This revealed a group of eight fluorescent spots suggestive of the coumarin array demonstrated by Stanley and Vannier[4,6]. Extracts were then subjected to downward chromatostrip development[6] and separation of four of the compounds was achieved in amounts adequate for qualitative ultra-violet spectral measurements. Comparison of R_F values with known coumarin compounds and ultra-violet absorption spectra tentatively identified these four compounds as 5-geranoxypsoralen (bergamottin), 5-geranoxy-7-methoxycoumarin, 8-geranoxypsoralen and 5,7-dimethoxycoumarin (limettin) (Table 1).

Table 1

Compound	$R_F \times 100$*	Ultra-violet absorption maxima (mµ)
5-Geranoxypsoralen	68	251, 259, 269, 310
5-Geranoxy-7-methoxycoumarin	64	246, 256, 325
8-Geranoxypsoralen	40	244, 250, 265, 300
5,7-Dimethoxycoumarin	25	246, 256, 325
Oxypeucedanin hydrate	5	250, 259, 268, 310
Byakangelicin	0	241, 249, 270, 313

* On silicic acid chromatostrips (refs. 5, 6). Irrigation solvent: 25 per cent ethyl acetate in *n*-hexane (v/v).

The possibility remained that the coumarin compounds detected in the juice could conceivably be present because of inclusion of lemon oil in the concentrate. This could come about during the mechanical reaming of the fruit resulting from the rupture of the oil sacs releasing small amounts of oil into the juice[7].

In order to determine whether these coumarin compounds were present in oil-free lemon juice the following experiment was performed.

Thirty-six lemons were thoroughly scrubbed and washed in a hot detergent solution and rinsed with water. The lemons were then allowed to soak in hot water for about 30 min.

The epicarp (flavedo) was carefully stripped from each fruit by means of a stainless steel knife, and the fruit rinsed in cool water. The mesocarp (albedo) and segment membranes of the fruit were then removed and the lemons quartered. Finally the central vascular bundle and all the seeds were removed.

The sectioned juice sacs were homogenized in a blendor for 15 min., and the homogenate filtered to remove any remaining membrane material. 250 gm. of this material were extracted with three 100-ml. portions of low-boiling petroleum ether, the extracts combined, dried over anhydrous sodium sulphate, filtered and the solvent removed under reduced pressure on a steam-bath. A pale yellow oil resulted. A small amount of the oil (about 0·01 ml.) was applied to a silicic acid chromatostrip[6] and irrigated with a solution of 25 per cent ethyl acetate in *n*-hexane. Examination of the strip under ultra-violet light (2540 A.) revealed eight distinct spots or zones.

Several downward chromatostrips[5] were run, the individual zones scraped from the strip, each eluted with 95 per cent ethanol and the eluates filtered. The ultra-violet spectrum of each eluate was then taken.

Comparison of R_F values with known coumarin compounds and ultra-violet absorption spectra tentatively identified five of these compounds as 5-geranoxypsoralen (bergamottin), 8-geranoxypsoralen, 5,7-dimethoxycoumarin (limettin), oxypeucedanin hydrate and byakangelicin (Table 1).

To date, insufficient amounts of these compounds have been isolated from the juice for more precise analytical examination; but this work is in progress.

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Further Aspects of Humus Decomposition

Recent experiments have shown that the characteristic flush of decomposition that follows the wetting of a dry soil can be partly prevented by the addition of 0·5 gm. of activated charcoal (per 30 gm. soil) and almost completely prevented by 1·5 gm. or more (Fig. 1). When the soils were then oven-dried and re-wetted without further treatment a similar result was obtained. When a slowly decomposing moist soil was treated with ether vapour under vacuum and the excess vapour then removed, a similar flush of decomposition resulted which was also repeated with successive treatments. Here, however, the flush of decomposition was not inhibited by charcoal.

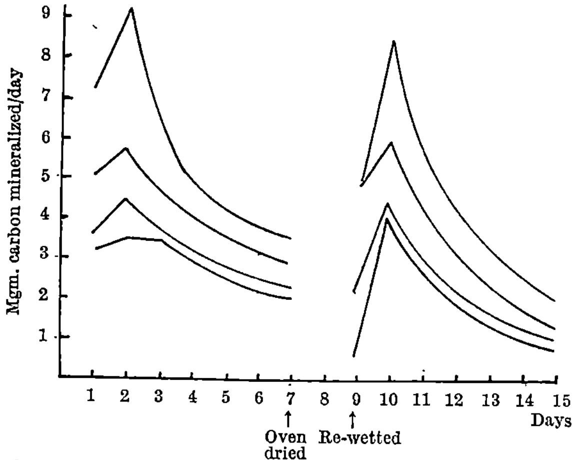

Fig. 1. Curves, from top to bottom: no carbon; 0·5 gm. carbon; 1·0 gm. carbon; 1·5 gm. carbon

These results afford an insight into the factors involved in humus decomposition and the partial sterilization of soils. Soil drying increases the amount of organic material later going into solution and when this is adsorbed by the charcoal the flush of decomposition is inhibited. Ether vapour has, however, been found here to have no effect on the amount of organic material that will dissolve. Nevertheless, the flush of decomposition still occurs and this may be ascribed to the high microbial activity associated with the youthful phase of the newly developing population and the presence of dead microbial cells which can serve as readily available substrate[1].

Since heat causes diffusion of amino-acids from within the cells[2], it is possible that the compounds adsorbed by the charcoal are amino-acids or similar microbially derived compounds and that these, serving as available substrate, are responsible for the flush of decomposition following the wetting of an oven-dry soil. Ether, on the other hand, reduces cell permeability[3] and was found here to be ineffective in increasing the amount of organic material going into solution. Charcoal, therefore, has no effect after ether treatment in inhibiting the flush of decomposition which must depend on the utilization of relatively intact dead cells as substrate. Clearly, the marked decomposition that follows partial sterilization is not necessarily dependent on increased solubility of substrate. The main factor involved appears to be microbial death, whether accompanied by lysis of the cell contents or not, the remains then serving as available substrate when normal conditions are restored. The newly developing population will also be more active at first than later on.

The results of the charcoal experiment conform with what has been said. It will be noted that the magnitude of the second flush of decomposition is related to the magnitude of the first. The larger this is the bigger the microbial population will be and the greater the amount of substrate available, after killing, for the succeeding population. Such a sequence of decompositions can, however, only be maintained if substrate additional to that supplied by the micro-organisms is available, since much of the microbially derived substrate is lost as carbon dioxide during its utilization by the newly developing population. It has been reported[4] that when decomposable material is added to a soil a highly active microbial population develops with consequently enhanced humus decomposition while the supply of energy material lasts. Microbially derived substrate could serve a similar function, the succeeding population building up to an equilibrium-level depending not only on the amount of microbially derived substrate available but also on the kind and amount of humus present. This would explain why the sequence of decompositions are of approximately equal magnitude and are also dependent on the carbon content of the soil.

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Chlorine Deficiency in Soils

In the past five years chlorine has been shown to be an essential micronutrient for a number of vegetable and crop plants[1,2]. More recently, the need for chlorine was demonstrated in the annual pasture plant, subterranean clover (*Trifolium subterraneum*, L.)[3]. The solution culture medium used in these experiments was prepared by adding highly purified inorganic salts to twice-distilled water. In addition, the plants were grown in glasshouses fitted with filters to purify the incoming air.

The economic importance of chlorine as a plant nutrient will depend on whether or not plant growth in the field is limited by chlorine deficiency. Although a great deal of information has been accumulated regarding saline soils, there is little known of the occurrence of soils very low in chlorine. As a first step in investigating this problem, I collected soil samples from various locations in California. These were selected with regard to distance from the sea, high altitude, heavy rainfall or with permeable, well-drained soil profiles. It was thought that these conditions were likely to produce soils low in chlorine. On analysis of saturation extracts by electrometric titration, the two soils lowest in chlorine were found to contain only three to five micro-equivalents per 100 gm. These soils, a Holland sandy loam and a Cometa coarse, sandy loam, were found in the foothills of the Sierra-Nevada Range at points about 65 miles apart, and 100 miles from the ocean. Both sites were carrying a poor growth of annual pasture plants.

Subterranean clover (var. Mt. Barker) was planted in 2·4-kgm. pots containing these soils, and then

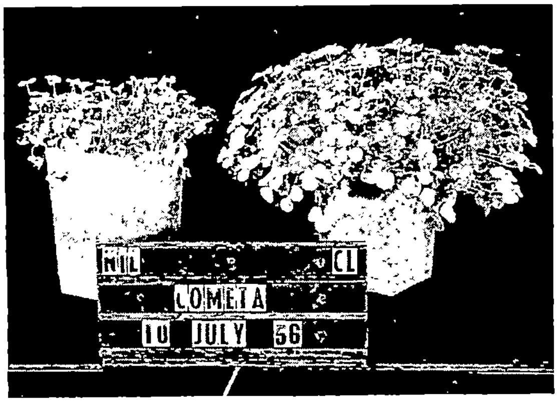

Fig. 1

grown in a glasshouse at the University of California, Berkeley. To half the pots, ample chlorine for plant growth was added; in the others the only chlorine present was that in the soil. All the pots were supplied with a complete nutrient solution, lacking only in chlorine. The plants were watered with twice-distilled water. At intervals of 3–4 weeks the plants were mown back to simulate the defoliating effects of grazing.

After three and a half months, acute symptoms of chlorine deficiency were present on the 'minus-chlorine' plants on both soils, and the top yields of these plants were reduced. The type of culture technique and the yield effects on one soil type are shown in Fig. 1. Under the conditions of the experiment these soils did not contain sufficient chlorine to grow the clover plants even to the flowering stage.

A similar exploratory soil survey has now been carried out in Western Australia. Here, despite the areas of saline soils and salt lakes in the inland agricultural areas, three soils containing only 3–5 micro-equivalents of chlorine per 100 gm. were found. Two of these soils were potted in 5-kgm. containers in the glasshouse at Perth. They were then planted with subterranean clover. Again, as in the Californian trial, acute chlorine deficiency symptoms developed before the plants reached the flowering stage. In this experiment no air filters were used on the glasshouse, which stands only 150 yards from a salt-water estuary and five miles from the ocean.

The amount of chlorine present in the soils described is equivalent to about 4 lb. per acre—6 in., or the depth of the pots used. Much of the chlorine in soils is derived from the rainfall. Hence, it is of interest to note[4] that five rural areas in Victoria receive little more than this amount in the annual rainfall.

This work is continuing and will be reported in more detail elsewhere. However, it is apparent that a number of soils contain insufficient chlorine for plant growth when the plants are repeatedly defoliated under glasshouse conditions.

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Use of Loosely Linked Genes to estimate Chromatid Interference by Tetrad Analysis

STRICKLAND[1] has applied to tetrad data for *Aspergillus nidulans* the method I have suggested[2] for estimating the magnitude of chromatid interference between cross-overs when loosely linked genes are used. The principle underlying this method is as follows: Consider three linked loci X, Y and Z spaced along a chromosome in that order. By means of tetrad analysis one can distinguish a number of tetrad genotypes. Certain of these, called (*a*), (*b*) and (*c*), respectively, are most simply interpreted as resulting from the following cross-overs at meiosis: (*a*) One cross-over between X and Y and another between Y and Z involving the same chromatids, that is, a two-strand double cross-over. (*b*) One cross-over between X and Y and another between Y and Z, with a three-strand relationship. (*c*) One cross-over between X and Y and another between Y and Z involving the other two chromatids, that is, a four-strand double cross-over. With closely linked genes, the frequencies of (*a*), (*b*) and (*c*) provide accurate information about the frequencies of two-, three- and four-strand relationships between cross-overs. If the genes are loosely linked, these tetrad genotypes can also arise as a consequence of a three-strand double cross-over between X and Y (or Y and Z) and a third cross-over between Y and Z (or X and Y), but the strand-relationships with the third cross-over are two- or four-strand for genotype (*b*) and three-strand for genotypes (*a*) and (*c*). In other words, the occurrence of these triple cross-over tetrads will hinder the detection of chromatid interference by tending to obscure differences from the 1 : 2 : 1 proportion of genotypes (*a*), (*b*) and (*c*). This is the ratio expected with no chromatid interference. The frequency of these inconvenient triple cross-over tetrads can be estimated from the observed frequency of another tetrad genotype (*d*), which results from a four-strand double cross-over between X and Y (or Y and Z) and a third cross-over between Y and Z (or X and Y). In this way, allowance can be made for the effects of triple cross-overs.

If the frequencies of tetrads of genotypes (*a*), (*b*) and (*c*) do not differ significantly from a proportion of 1 : 2 : 1, there are two alternative explanations, namely, either (1) successive cross-overs occur at random (or nearly so) as regards the pair of strands involved, or (2) there is chromatid interference, but its occurrence has been obscured owing to triple cross-overs. In the latter event, analysis of a larger number of tetrads should reveal a significant deviation from 1 : 2 : 1, since only a minority of the tetrads are likely to arise from triple crossing-over. Thus, from his analysis of 264 tetrads from "cross 2", Strickland[1] obtained frequencies of genotypes (*a*), (*b*) and (*c*) of 34, 66 and 24, respectively. These frequencies do not differ significantly from a proportion of 1 : 2 : 1 ($\chi^2 = 2{\cdot}13$ $n = 2$, $P = 0{\cdot}5$–$0{\cdot}3$). There were 15 tetrads of genotype (*d*) and consequently the contribution to the (*a*), (*b*) and (*c*) genotypes due to triple cross-overs can be estimated (as a first approximation) to be $\frac{66}{24} \times 15 = 41{\cdot}25$, or 33·3 per cent. Thus it is probable that about two-thirds of the 124 tetrads of genotypes (*a*), (*b*) and (*c*) have resulted from double cross-overs and consequently have provided valid information about the strand-relationships between cross-overs. Analysis of a larger sample of tetrads will therefore be expected to provide a significant deviation from 1 : 2 : 1 if there is chromatid interference. However, from Strickland's published data it is not justifiable to conclude that there is such interference, since hypothesis (1) above has not been ruled out. In other words, the 'correcting' of chromatid interference data to allow for triple cross-overs can be used for estimating the magnitude of such interference but not for detecting its occurrence in the first place.

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Cytochromes of *Rhizobium*

LEGHÆMOGLOBIN, the red pigment associated with the bacteroid form of *Rhizobium* in effective legume root nodules, appears to be closely linked with the nitrogen fixation process[1], but its connexion with *Rhizobium* respiration is disputed[2,3]. We are endeavouring to clarify the latter problem by a comparative study of respiratory pigments in several free-living *Rhizobium* strains and the related root nodules.

While observing with a microspectroscope the reduction of leghæmoglobin in fresh homogenates of effective soybean or clover nodules made anaerobic by endogenous respiration, we saw also a sharp absorption band appearing near 551 mμ. This was later identified as the α-absorption band of reduced bacteroid cytochrome *c*, and it therefore appeared that biological reduction of the two pigments could be closely related. A smaller amount of *b*-type cytochrome, with α-absorption band at 562 mμ, was also seen in the washed bacteroids isolated from these homogenates, but no cytochrome *a* could be detected even when dense bacteroid suspensions in 50 per cent (v/v) glycerol were examined in the spectroscope at liquid air temperature (cf. Hartree[4]). Typical cytochrome *a*, *b* and *c* absorption bands as described by Smith[5] were readily observed in the same *Rhizobia* grown on an agar medium, showing that, in the transition from free-living to bacteroid form, *Rhizobium* loses its cytochrome *a*.

Many micro-organisms suffer an adaptive loss of cytochrome *a* when grown anaerobically[6], and as the nodule interior is assumed to be at a very low oxygen tension[2] we then made a quantitative comparison of cytochrome components in effective soybean nodule bacteria and the same *Rhizobium* strain grown in pure culture at high and low oxygen tensions. Cytochrome concentrations were measured in a Bellingham and Stanley reversion microspectroscope following the general procedure described by Hartree[4]. The comparison prism of this instrument was remounted so that the bacterial spectrum and the comparison spectrum (of reduced mammalian cytochrome *c* contained in a wedge-trough) were viewed simultaneously. By turning the reversion screw, the α-absorption band of the standard cytochrome *c* was matched in turn against each cytochrome band of the bacterial spectrum. An arbitrary assumption was made that the α-absorption bands of all components had the same specific extinction coefficient as cytochrome *c*.

These measurements (Table 1, *A*) showed an increase of cytochromes *b* and *c* in effective nodule bacteria (bacteroids) and cultured *Rhizobium* grown at low oxygen tension, and confirmed the complete loss of cytochrome *a* from bacteroids. Cytochrome *a* had decreased in amount, but not disappeared from the cultured organisms grown at an oxygen pressure of 0·02 atm. We were unable to grow *Rhizobium* in liquid culture at oxygen tensions lower than this and so could not decide whether the complete disappearance of cytochrome *a* from bacteroids is solely due to a very low oxygen tension inside the effective nodule. Subsequent measurements (Table 1,*B*) on *Rhizobium* isolated from ineffective soybean nodules (which were devoid of leghæmoglobin and caused no detectable nitrogen fixation), made this explanation seem unlikely, as these bacteria still contained a small amount of cytochrome *a*.

Table 1. CYTOCHROME CONCENTRATIONS IN *Rhizobium* FROM ARTIFICIAL CULTURE AND NODULES

Rhizobium strain (5)	Origin	Cytochrome component	α-Band (mμ)	Conc. in pellet (m*M*)	Nitrogen content (mgm./ml. of pellet)
A					
505 Wisconsin	Culture Oxygen pressure =0·2 atm.	*c*	551	0·096	38
		b	562	0·036	
		a	602	0·023	
505 ,,	Culture Oxygen pressure =0·02 atm.	*c*	551·5	0·160	37
		b	563	0·044	
		a	602·5	0·012	
505 ,,	Effective nodule	*c*	551·5	0·270	29
		b	562·5	0·059	
		a	—	0	
B					
507 ,,	Culture Oxygen pressure =0·2 atm.	*c*	551·5	0·050	28
		b	562·5	0·038	
		a	601·5	0·021	
507 ,,	Ineffective nodule	*c*	551·5	0·108	27
		b	562·5	0·033	
		a	602	0·006	

The bacteria were isolated from vigorously aerated log-phase liquid cultures and from 6–7-week-old nodules of 'Lincoln' strain soybean grown in the glasshouse. After checking for purity the washed *Rhizobium* suspensions were reduced with dithionite, and the pellets obtained after high-speed centrifuging (30,000*g*) were placed in demountable spectrophotometer cuvettes of 1, 2 or 3 mm. light path. Cytochrome contents, determined as described in the text, are expressed as millimolar concentrations in the packed pellets. Total nitrogen values were determined by the Kjeldahl method.

Work is at present in progress to determine what function cytochrome *a* has in the terminal oxidase system of *Rhizobium*[7], and whether its unique disappearance from bacteroids is accompanied by the appearance of another oxidase which might react specifically with leghæmoglobin.

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Reproductive Disturbances of Romney Ewe Lambs grazed on Red Clover (*Trifolium pratense*) Pastures

On March 10, 1958, 111 Romney ewe lambs (group *A*) which had grazed continuously since weaning (December 12, 1957) on pastures dominant in red clover were joined with an additional 92 Romney ewe lambs (group *B*) for studies of their breeding season. This latter group had grazed, since weaning (December 11, 1957), on perennial rye-grass–white clover pastures. Vasectomized, ochred rams were run with these lambs from March 17, 1958, all being grazed together on perennial rye-grass–white clover pastures. All lambs were weighed on March 19, group *A* and group *B* having the same average live weight (71 lb.). On the same day, that is, within two days of joining with teasers, 29 lambs from group *A* but none from group *B* were found to have been marked. This sudden onset of œstrus from one group of lambs was unexpected in view of the previous results[1] on the breeding season of Romney ewe lambs. Owing to the relatively early age at first œstrus shown by these lambs, laparotomy was performed within five days of observed œstrus to determine whether ovulation had occurred. Both the left and right ovaries of eight lambs were examined without finding any evidence of the existence of corpora lutea. Graafian follicles of varying sizes, however, were seen on most ovaries.

Red clover[2], like Australian subterranean clover[3], has been reported to contain substances with œstrogenic effects. In order to investigate whether the observed œstrus without ovulation in the lambs described earlier could have resulted from the œstrogenic activity of the red clover dominant pastures, random samples of this pasture were collected on March 25. These samples, consisting almost entirely of red clover, were freeze-dried, ground in a hammer mill and fed to 21-day-old, ovariectomized white mice in an attempt to detect the presence of substances with œstrogenic effects by the mouse uterine weight technique[4]. The control diet consisted of 50 per cent (by weight) barley meal and 50 per cent butter milk powder. The 'clover' diet was made up from 75 per cent (by weight) control diet and 25 per cent 'clover' pasture. Results from two feeding periods of 10 and 11 days respectively were combined and are presented in Table 1.

Table 1. THE EFFECTS OF FEEDING 'CLOVER' DIET TO MICE (SEVEN MICE PER GROUP)

Treatments	Control	'Clover'
Initial body-wt. (gm.)	8·76	8·64
Final body-wt. (gm.)	15·10	10·07
No. of vaginal openings	1*	7
Mean and S.D. of uterine wt. (mgm.)	5·36±0·99	10·57±2·67

* Suspected to be an artefact.

These results indicate that the 'red clover' pastures contained substances which have potent œstrogenic effects. It is also probable that ingestion of 'red clover' pastures over a period of time as occurred in the present case has induced œstrus without ovulation in the lambs. It is of interest to note that Australian workers[5-7] have repeatedly pointed out that lowered fertility of breeding ewes grazing subterranean clovers was not attributable to the failure of œstrus as detected by ochred rams. If the present findings are also applicable to breeding ewes, then under certain conditions, 'œstrus without ovulation' may represent an additional complication in studies of female infertility in sheep.

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Molybdenum Content of Equine Liver Tissue

The discovery that molybdenum is a component of the enzyme xanthine oxidase[1] has directed interest to the presence of this element in animal tissue, particularly liver. I have found that adult horse liver tissue contains highly variable levels of molybdenum.

125 specimens of adult horse liver were obtained from a Cambridge slaughter-house during a period of eight months. The liver samples were dried at 100° C. and the dried material analysed for molybdenum by the thiocyanate–stannous chloride method of Dick and Bingley[2]. The range of molybdenum content of the tissues is shown in Fig. 1.

While 109 of the 125 livers were within the range 3–19 p.p.m., five livers had molybdenum-levels of 42·0, 47·6, 54·8, 76·4 and 84·6 p.p.m. of tissue dry-matter. The total ash contents of these latter five samples were within the normal range.

Comparing these figures with the data given by Underwood[3], it has been found that molybdenum accumulates in the liver to a greater extent in the horse than in cattle or sheep. The reason for the accumulation of this element is not known, but it is

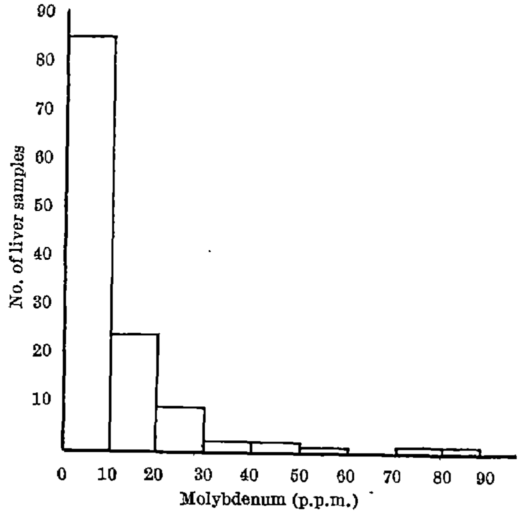

Fig. 1. Range of molybdenum contents of 125 samples of equine liver

possibly associated with the advanced age of individual animals. The rise in molybdenum may also reflect changes in the enzyme activity of the liver with age.

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Serological Test for Determination of Parentage in Cattle

The antigenic individuality of red cells of cattle was noted in 1910 [1], and studies conducted since 1940 by many workers have made it possible to identify more than fifty blood factors. The number of blood-group combinations is very large, and in practice it is difficult to find two individuals with the same combination. Identification of red cell antigens in cattle and knowledge of the mode of inheritance of these characters have been found to have a practical application among others in the exclusion of paternity and the control of pedigree. A condition for the efficacy of these tests is the possession by the laboratory of a large number of immune sera (reagents).

In 1950 Löns[2], basing his argument on antigenic individuality of human red cells, proposed the method of determining paternity by the use of polyvalent immune serum. He assumed that the polyvalent serum absorbed by the red cells of the father and the mother would react with the red cells of all other persons with the exception of the red cells of a child of the couple the red cells of which were used for the absorption. This method did not yield the expected results and control tests proved it to be useless.

Prof. F. Milgrom suggested to us that an analogous method might be successful for the determination of parentage in cattle.

In order to obtain polyvalent sera, rabbits were injected with red cells of 20 different cattle. The resulting sera hæmolysed in high titre the red cells of all cows, and the absorption of the serum with red cells of one animal removed the antibodies for the red cells used for absorption and left antibodies for all other samples of blood. Out of nine immune sera obtained, two (Nos. 919 and 345) could be successfully used in further tests; their absorption was relatively easy. The absorption conditions were specific for each serum. The best absorption formula was determined by a procedure similar to that used in determining the method of absorption of rabbit anti-*M* or anti-*N* antisera (of the *MNSs* system in humans). Sera Nos. 919 and 345 were absorbed in dilutions of 1 : 25 and 1 : 45 respectively. The volume of red cells used for absorption ranged from 1/1 to 1·5/1, depending on the antigen power of the red cells. The absorption time for serum 919 was 2·5 hr. and for serum 345, 4 hr. Further details concerning the technique employed will be described elsewhere by one of us (J. R.).

For absorption, a mixture of red cells of the mother and the father was used. After absorption, a hæmolysis test was made with the red cells of the offspring. As a control, tests were performed with red cells used for absorption and with red cells of about twenty other cattle. These red cells came from: (1) the offspring of only one of the couple the red cells of which were used for the absorption—these cattle are denoted in Table 1 as 'related'; and (2) cattle regarded as 'unrelated'. These were unrelated or showed a lesser degree of relationship than the cows in group 1. As a complement, guinea pig serum diluted 1 : 10 was used. This serum was previously controlled to see that it did not contain antibodies for cattle red cells.

Table 1. Results of Tests with the use of Two Polyvalent Sera

Material tested	Results obtained with serum No. 919: Number tested	919: Parentage excluded	345: Number tested	345: Parentage excluded	919+345 together: Number tested	919+345 together: Parentage excluded
Offspring	41 *1·000**	0 *0·000*	41 *1·000*	0 *0·000*	41 *1·000*	0 *0·000*
Related individuals	142 *1·000*	80 *0·563*	146 *1·000*	81 *0·554*	140 *1·000*	86 *0·614*
Unrelated individuals	663 *1·000*	528 *0·796*	662 *1·000*	527 *0·796*	650 *1·000*	579 *0·891*

* Figures in italics denote the percentage of the number tested.

After absorption the sera never reacted with the red cells employed for absorption nor did they react with the red cells of cows that were the offspring of the couple the red cells of which were employed for absorption. In contrast to this, these sera reacted with the majority of control red cells both with the samples from the 'related' and 'unrelated' heads of cattle. 35 families with 41 offspring were studied. Control tests were made with 140 'related' and 650 'unrelated' individuals. Table 1 gives the results of our tests.

From these results it appears that the use of two polyvalent sera makes possible the exclusion of about 89 cows out of 100 that were not the offspring of the couple the red cells of which were used for absorption. When the tested individual is an offspring of only one of the heads the red cells of which were used for absorption, exclusion of parentage is still possible in 61 per cent of cases. The first of the figures given, 89 per cent, is almost the same as giving positive indication of the proper pair of parents in the case when it was not possible to exclude the parentage.

It seems that the method described will be of practical use in checking doubtful parentage since the method is incomparably more simple and more within the scope of an ordinary laboratory than the method employed hitherto in which many reagents difficult to obtain are used. The efficiency of the method is quite good; this method could be increased if a third polyvalent serum were used.

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Variations in the Insecticide Tolerance of Insects

Recent communications[1,2] on the variance of the dosage-mortality response of strains of housefly and mosquito susceptible and resistant to insecticide serve to emphasize that, although there is considerable information on the inheritance of resistance to insecticide in some insects, especially houseflies[3], *Drosophila*[4] and now mosquitoes[5], there has as yet been no direct estimate of how much of the unselected tolerance is genetically determined, how much is due to environmental effects. Beard[6], who first directed attention to the possibilities, considered the non-genetic variation might so predominate as to overwhelm the genetic components.

One would not wish to dispute the contention[1] that insect populations comprised of a single resistance-susceptibility genotype are likely to be less variable in their tolerances than are populations containing all possible resistance-susceptibility genotypes. But that fact is scarcely relevant to what Hewlett originally suggested[7], namely, that a portion of the tolerance variance is susceptible to manipulation without any change in gene frequency. That this interpretation was, at least in part, intended is shown by the example selected[8], the decrease in variance of the tolerance found with a DDT-resistant strain of housefly when increasing amounts of the insecticidally inert synergist DMC were added to the applied DDT. One point which strongly supports Hewlett's hypothesis, but has not been commented upon, is the very obvious increase in variance with the smallest amount of DMC compared with that found with DDT alone[8].

It is usual to assume that the genes for resistance are extremely rare in Nature, or, as stated by Wilson-Jones and Davidson[1], so infrequent that an average sample of wild insects is unlikely to contain resistant genes. This assumption has been made repeatedly in attempts to explain the often rather slow emergence of resistance in the field, but, as was recently pointed out[9], it is unlikely that this assumption of rarity is correct. Indeed, the only quantitative work as yet available on the frequency of resistant genes in wild populations showed that there may be as many as 12 per cent of dieldrin-resistant heterozygotes in the *Anopheles gambiae* populations of areas as yet untouched by dieldrin[10]. Finally, laboratory populations originate as samples from wild populations, most but not all attempts in the laboratory to induce insecticide resistance are successful, and sometimes resistance to a number of insecticides can be developed sequentially[11].

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Fluorescent Mast-Cell Reaction in Precancerous Skin of the Lizard *Lacerta agilis*

The mast-cell reaction of the mouse skin, painted with tar or carcinogenic hydrocarbons, has been known for a long time[1]. According to several authors, these cells show a golden-brown fluorescence when examined under the microscope in ultra-violet light[2], though other investigations give some evidence to the contrary[3].

Recently, it has been established that the mast cells of the mouse and the rat contain not only histamine but also 5-hydroxytryptamine[4]. This substance can be converted into a fluorescent β-carboline derivative by the action of formaldehyde, and in the mast cells of the precancerous mouse skin it reaches a concentration which is normally only achieved by the cells of the enterochromaffin system[5].

In the mastocytosis of the mouse skin after painting with 9,10-dimethyl-1,2-benzanthracene in acetone it could be demonstrated to direct assay and by paper chromatographic examination that the fluorescent substance of the mastocytes is the 5-hydroxytryptamine derivative β-carboline[2].

Continuing these investigations, we examined a cutaneous carcinoma of a lower vertebrate, namely, the squamous-cell carcinoma of the lizard *Lacerta agilis*. This tumour seemed pre-eminently suitable for this purpose, because a distinct precancerous phase occurs in its development[6,7]. At first we had seven tumour-bearing animals, but by extending the material we finally had 104 specimens at our disposal.

From these specimens the precancerous portions of the skin were excised. The examination of the mast cells was carried out with frozen sections (cut in a horizontal as well as in a vertical direction), free-hand sections and tissue spreads prepared from dermal scrapings. The skin material, fixed in 10 per cent formalin or otherwise, was examined under the microscope in ultra-violet light. Then the material was stained either with acetylated sudan black for phospholipids[8] or with toluidine blue for mast cells.

Just as in the mouse, the mast cells of the precancerous skin of the lizard gave a golden-brown fluorescence in ultra-violet light, but only after treatment with formalin. The fact that a non-fluorescent precursor substance can be extracted from the mast cells by prolonged treatment of the skin tissue with acetone suggests that the fluorescence is a consequence of the action of formaldehyde on the above-mentioned substance. Acetone treatment apparently did not affect the ability of the mast cell granules to stain with either acetylated sudan black or with toluidine blue.

To establish the chemical identity of the fluorescing substance we prepared an extract of the precancerous lizard skin. For this purpose the dermal scrapings of the skins were homogenized in acetone, after which the extract was concentrated *in vacuo*. After the fats had been removed with petroleum ether the extract was treated with formaldehyde and could then be examined in ultra-violet light. The extract treated with formaldehyde exhibits the same golden-brown fluorescence as was found with the extract of mouse skin prepared in the same way[2]. A further extraction of the skin fragments with fat solvents failed to yield additional fluorescent material.

Like the mast cells of the precancerous mouse skin, the mast cells of the precancerous skin of the lizard probably contain a relatively large quantity of histamine and 5-hydroxytryptamine.

The source of 5-hydroxytryptamine is unknown; it may be either the inside or the outside of the precancerous epidermis. Possibly this substance plays an important part in the development of the squamous-cell carcinoma of the skin.

A. Stolk

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Amsterdam.
Aug. 29.

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Undergraduate Academic Record of Fellows of the Royal Society

The communication by Gross and Hudson in *Nature* of September 20, p. 787, shows an interesting difference between academic records of Fellows of the Royal Society who were respectively at Cambridge and at Oxford. Of those at Cambridge only about 77–78·5 per cent achieved a first, and in fact only about 55 per cent achieved a first in both parts of a tripos. The Fellows of the Royal Society who were at Oxford, on the other hand, graduated with first-class honours in about 97 per cent of cases.

The authors suggest that these interesting results are open to at least two interpretations: (1) that the Oxford examination is a more valid index of potential research ability; and (2) that the standards of the Oxford examinations are relatively lower than those of Cambridge. There is surely a very important third possible interpretation, namely, extra-curricular activities are far more interesting at Cambridge than at Oxford, and that in the widest sense the Cambridge education is therefore better.

The authors, strangely, make no comment on the fact that it seems to be three times as common for a Cambridge graduate to become a Fellow of the Royal Society, neither do they comment on the obvious fallacy of the whole investigation, namely, the opportunities for research offered to a young man at the beginning of his career. If these are, for example, only offered to those with a first-class degree, it is obvious that selection for the fellowship of the Royal Society in later years will be almost restricted to those who had first-class degrees. The method will fail to show whether there is a number of potentially good investigators among those with second-class degrees who have never been given the opportunities for a career in research.

Robert Platt

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We certainly agree with Prof. Platt that the difference between the Oxford and Cambridge results is open to the third possible interpretation that he suggests, and we would welcome from him any suggestion as to how we could measure the "more interesting" nature of the "extra-curricular activities" at Cambridge.

We find nothing strange in "the fact that it seems to be three times as common for a Cambridge graduate to become a Fellow of the Royal Society" since there are almost three times as many science graduates from Cambridge as there are from Oxford.

During the period 1920–39, approximately 4,700 natural scientists, 1,400 mathematicians and 1,800 engineers graduated from Cambridge, while only 2,600 natural scientists (including engineers) and 400 mathematicians graduated from Oxford.

If we understand Prof. Platt's last paragraph correctly, we consider it to be true but irrelevant to our study and to the general problem under consideration. Obviously, as he points out, if only students with first-class degrees are given opportunities for research, the Fellows of the Royal Society will be drawn largely from this group. Our point is that, whatever selection procedures were used in the past, a considerable minority of the scientists elected to the Royal Society did not receive first-class degrees. From this we conclude that it may be unwise to use class of degree as the primary criterion for the award of research grants.

C. Gross
L. Hudson

Psychological Laboratory,
Cambridge.

Cancer and Smoking

In a letter published in *Nature* of August 30, p. 596, Sir Ronald Fisher quoted figures confirming previous observations that smoking habits are more similar in identical than in fraternal pairs of twins even when the identical pairs are reared apart. The result can be interpreted as showing that, like almost every trait, mental or physical, previously tested by the twin method, smoking habits are, to a greater or lesser degree, dependent upon genetical constitution. It is, however, difficult to appreciate the relevance of this demonstration to the problem as to whether or not cigarette smoking causes lung cancer.

The association between epithelioma and the occupation of sweeping chimneys has been well known in the past. Not improbably it could have been proved that identical twins were more often both chimney sweeps than would have been expected by chance. Such a finding would not have influenced the case for assuming a strong causal connexion between soot irritation and epithelioma.

Nevertheless, there are perhaps hitherto unexplored ways in which twin data might be usefully employed in the study of the effects of tobacco on the lungs. Pairs of identical twins, whose smoking habits were discordant, could be followed up with special reference to possible development of lung disorders in one or both members.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 27

Institute of Actuaries (in Staple Inn Hall, High Holborn, London, W.C.1), at 5 p.m.—Mr. F. M. Redlington: Presidential Address.

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. A. T. Grove: "Geomorphology of the Tibesti Region".

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. J. Swaffield and Mr. D. L. Richards: "Rating of Speech Links and Performance of Telephone Networks"; Mr. D. L. Richards and Dr. J. Swaffield: "Assessment of Speech Communication Links".

Royal Aeronautical Society (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. D. J. Farrar: "The Bloodhound".

Tuesday, October 28

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. J. Z. Young, F.R.S.: "Octopuses, Squids and Cuttlefishes".*

University of London (at Queen Mary College, Mile End Road, London, E.1), at 1.30 p.m.—Prof. G. E. Newell: "The History of a Beach".*

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 2 p.m.—Symposium on "Aluminium Pressure Vessels".

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Electronic Control of Machine Tools" opened by Mr. D. T. N. Williamson.

University of London (in the main Chemistry Theatre, Royal College of Science, Imperial College of Science and Technology, London, S.W.7), at 5.30 p.m.—Dr. H. Zemanek (Vienna): "Some Automata of the 18th Century".*

Society of Instrument Technology (at Manson House, Portland Place, London, W.1), at 6 p.m.—Dr. L. Essen: "Basic Measurements of Time and Frequency".

Plastics Institute, London and District Section (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Mr. B. S. Dyer: "Vinyl Chloride Polymers—Their Design and Application".

Institution of Electronics (in the Assembly Hall of the University of London Institute of Education, Malet Street, London, W.C.1), at 7 p.m.—Dr. F. E. Flood: "Electronic Telephone Exchanges".

Royal Institute of Chemistry, London Section (at the Medway College of Technology, Maidstone Road, Chatham, Kent), at 7.30 p.m.—Prof. R. S. Nyholm, F.R.S.: "Recent Advances in Structural Inorganic Chemistry".

Wednesday, October 29

University of London (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. P. Fourman: "Magnesium Metabolism".*

Society of Chemical Industry, Food Group—Nutritional Panel (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Meeting on "Nutritional Problems in Polar Regions". Lieutenant Commander A. B. Erskine, R.N.: "Sledging Problems"; Major J. M. Adam, R.A.M.C.: "Use of M.R.C. Sledging Rations".

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Dr. M. Prutton: "Ferro-Electrics and Computer Storage".

Society of Chemical Industry, London Section (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 6.30 p.m.—Programme of Scientific Films pertaining to Atomic Energy. "The Dounreay Sphere"; "Engineering at Calder Hall"; "Criticality".

British Association of Chemists (at the Royal Society of Medicine (West Hall), 1 Wimpole Street, London, W.1), at 7 p.m.—Mr. J. Wilson: "Grant-Aided Research Associations" (Hinchley Memorial Address).

Thursday, October 30

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. L. B. Keeble: "The Role of Town Planning in Modern Society".*

Friday, October 31

Institution of Mechanical Engineers (in conjunction with the Applied Mechanics Group, at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. W. Johnson: "Estimation of Upper Bound Loads for Extrusion and Coining Operations".

North East Coast Institution of Engineers and Shipbuilders (in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne), at 6.15 p.m.—Sir John Cockcroft, O.M., F.R.S.: "Nuclear Power for the Propulsion of Commercial Shipping" (Andrew Laing Lecture).

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. J. D. Bernal, F.R.S.: "The Structure of Liquids".

Saturday, November 1

Mammal Society of the British Isles (in the Meeting Room of the Zoological Society of London, Regent's Park, London, N.W.1), at 10.30 a.m.—Symposium on "Mammals in British History and Prehistory".*

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. C. P. Mountford: "The Aborigines of the Central Australian Deserts".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Advisory Officer (with a degree in science or agriculture, preferably with honours, and experience in investigations or research concerning poultry husbandry) in Poultry Husbandry—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (October 31).

Experimental Physicists (preferably with an honours degree in physics or equivalent and a sound experimental physics background) in the Research and Development Department, Central Electricity Generating Board for work on nuclear reactors, particularly on experimental reactor physics during the commissioning of civil nuclear power stations—The Personnel Officer, Central Electricity Generating Board, 24–30 Holborn, London, E.C.1, marking envelope "Confidential—Ref. N/308" (November 3).

Reader (with high academic and research qualifications) in the Department of Physics; and a Lecturer or Assistant, Grade B (preferably with teaching and research experience), in the Department of Physics—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (November 7).

Assistant Experimental Officer (with a pass degree or equivalent) in the Department of Physiology and Plant Culture, for duties concerned with day-to-day routine work on plant studies in controlled environments—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (November 8).

Assistant in the Department of Botany—The Secretary, The University, Edinburgh (November 8).

Assistant Librarian (honours graduate) in the Science Section of the College Library—The Registrar, University College of North Wales, Bangor, North Wales (November 8).

Lecturer or Assistant Lecturer in Sociology (with special reference to Social Anthropology)—The Secretary, The University, Exeter (November 8).

Technical Officer (Mass Spectrometer) (with a degree or diploma in chemistry or physics or equivalent qualifications) in the School of Chemistry, New South Wales University of Technology, Kensington, N.S.W., Australia, to maintain and operate a MS2 Metropolitan Vickers Mass Spectrometer—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (Australia, November 12).

Chairs in Botany, Chemistry, Mathematics, Physics, and Zoology in the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 15).

Lecturer in the Department of Social Anthropology, School of African Studies, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, November 15).

Scientific Officer (with a first- or second-class honours degree in biochemistry or a closely related subject, and preferably some research experience) in the Department of Biochemistry, to engage in the study of problems of plant biochemistry, in particular the influence of mineral nutrition on the enzyme content of leaves—The Secretary, The Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (November 17).

Lecturer in Civil Engineering at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 29).

Senior Lecturer or Lecturer in Mechanical Engineering at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 29).

Lecturer (with a degree in mechanical engineering of a recognized Commonwealth university, preferably at honours standard, or an equivalent qualification, and preferably experience of modern drawing office practice) in Mechanical Engineering at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 30).

Senior Lecturer and Lecturer in Geology at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

Assistant, Grade B (graduate well qualified in mathematics) in Mathematics—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex.

Assistant Lecturer, Grade B (with a good honours degree and preferably some teaching experience) in Chemistry at Brighton Technical College, to teach general chemistry up to G.C.E. advanced level standard and to assist with the teaching of inorganic chemistry at degree level—The Director of Education, County Borough of Brighton Education Committee, 54 Old Steine, Brighton, Sussex.

Biochemist, Senior or Basic grade (with a B.Sc. degree with honours in chemistry or biochemistry or an equivalent qualification)—The Group Secretary, Royal Hospital, Wolverhampton.

Biometrician (graduate in mathematics with an interest in biology) in the Section of Statistics, for duties which involve consultation on research on the design and analyses of experiments—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, Berks, quoting Ref. 58/17.

Chemist (with a Ph.D. or good honours degree, and preferably experience in, or knowledge of, electro, surface or theoretical organic chemistry), to join a team investigating the fundamentals of corrosion—The Director, Arthur D. Little Research Institute, Inveresk Gate, Musselburgh, Midlothian, Scotland.

Experimental Officers (at least 26 years of age with the H.N.C., or equivalent, in applied physics), to carry out experimental work in support of a programme of development of high speed trigatrons and associated circuitry—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. A.1968/1/34.

Lecturer in the Department of Mining and Fuels, for duties mainly concerned with the teaching of fluid mechanics and mine ventilation—The Registrar, The University, Nottingham.

Lecturer (with a degree in horticulture) in Horticulture at Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Lecturer (with an honours degree in chemistry and postgraduate experience of academic or industrial research) in Physical and Inorganic Chemistry—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

Mullard Research Fellow (with a good degree in electrical engineering or physics of a British university or equivalent qualification) in the Department of Electrical Engineering, for work on microwaves—The Secretary, University College, Gower Street, London, W.C.1.

Publications Editor/Librarian (with an honours degree in arts or science, some editorial experience, an interest in agricultural research, and preferably previous library experience or training and a knowledge of one or more foreign languages)—The Secretary, Grassland Research Institute, Hurley, near Maidenhead, Berks.

Research Assistant in Chemistry, to work in the field of complex metal reactions—The Secretary, Department of Chemistry, University College, Gower Street, London, W.C.1.

Seed Mycologist (with a degree in botany and preferably some postgraduate training); and a Research Assistant (with a degree in botany), for work on cereal germination—The Secretary, National Institute of Agricultural Botany, Huntington Road, Cambridge.

Senior Lecturer in Inorganic Chemistry, to plan and supervise the teaching of inorganic chemistry up to honours degree standard—The Principal, Royal Technical College, Salford.

Senior Research Assistant (Ph.D. standard and preferably some experience of electronics) in Physics, for a programme of work on the magnetic properties of thin films—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey.

Technician in the Nuclear Engineering Laboratory, for research work in electronics and nucleonics—The Registrar (NT), Queen Mary College (University of London), Mile End Road, London, E.1.

Technician or Junior Technician, for biochemical work in the Hospital Metabolic Unit—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

Zoologist or Physiologist (with a degree), to assist in the British Empire Cancer Campaign research on the biology of cancer including tissue culture—The Administrative Office, Mount Vernon Hospital, Northwood, Middx.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Serie A: Mathematical and Physical Sciences. No. 986, Vol. 250 (21 August 1958): Geomagnetic Dynamos. By A. Herzenberg. Pp. 543–585 (London: Royal Society, 1958.) 13*s*. [228

The Lambeth Conference 1958. The Encyclical Letter from the Bishops together with the Resolutions and Reports. Pp. 17. (London: S.P.C.K.; Greenwich, Conn.: Seabury Press, 1958.) 7*s*. 6*d*. [298

The Supply of Teachers in the 1960's—Correspondence between the Chairman of the National Advisory Council on the Training and Supply of Teachers and the Minister of Education, July 1958. Pp. 12. (London: H.M. Stationery Office, 1958.) 9*d*. net. [298

Sixth Report from the Select Committee on Estimates together with the Proceedings of the Committee, Session 1957–58—Treasury Control of Expenditure. Pp. 42. (London: H.M. Stationery Office, 1958.) 2*s*. net. [298

Pyrethrum Facts, 1958 Edition. Pp. 12. (London: Press and Public Relations, Ltd., 1958. Issued on behalf of The Pyrethrum Board of Kenya; The Pyrethrum Board of Tanganyika; and the Société Coopérative des Produits Agricoles.) [119

Leicester Museums and Art Gallery. A Catalogue of the Ophthalmosauridae in the Collections of the Leicester and Peterborough Museums. By R. M. Appleby. Pp. 47+7 plates. (Leicester: The Museums and Art Gallery, 1958.) [119

Anti-Locust Bulletin 31: Ecological Studies on Oviposition by Swarms of the Desert Locust (*Schistocerca gregaria* Forskål) in Eastern Africa. By G. B. Popov. Pp. ii+70 (51 figures). (London: Anti-Locust Research Centre, 1958.) 15*s*. [119

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Platinum in the Glass Industry: a General Survey. Pp. 45. (London: The Mond Nickel Company, Ltd., 1958.) [129

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Other Countries

Regional Research Centre of the British Caribbean at the Imperial College of Tropical Agriculture, Trinidad, B.W.I. Soil and Land-Use Surveys. No. 1: Jamaica—Parish of St. Catherine. By K. C. Vernon. Pp. 42. 20*s*. No. 2: British Guiana—The Rupununi Savannas. By R. F. Loxton, G. K. Rutherford and J. Spector. Pp. 33. 15*s*. (Trinidad: Imperial College of Tropical Agriculture, 1958.) [119

United States Department of Agriculture: Agricultural Research Service. Agriculture Handbook No. 136: Estimating the Amount of Crop Residue on a Field. By F. L. Dudley. Pp. 31. (Washington, D.C.: Government Printing Office, 1958.) 15 cents. [119

Annual Report of the Director of the Museum of Comparative Zoology at Harvard College, 1956–1957. Pp. 24. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1958.) [119

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 119, No. 1: Revision of Five African Snake Genera. By Arthur Loveridge. Pp. 198. Vol. 119, No. 2: Four New Rajids from the Gulf of Mexico. By Henry B. Bigelow and William C. Schroeder. Pp. 199–234. Vol. 119, No. 3: The General Histology and Topographic Microanatomy of *Australorbis glabratus*. By Chia-Tung Pan. Pp. 235–300+18 plates. Vol. 119, No. 4: Studies on the Ant Fauna of Melanesia. 3: Rhytidoponera in Western Melanesia and the Moluccas. 4: The Tribe Ponerini. By E. O. Wilson. Pp. 301–372. Vol. 119, No. 5: A New Species of Chelid Turtle, *Phrynops* (Batrachemys) Dahli, from Colombia. By Rainer Zangerl and Fred Medem. Pp. 373–390+2 plates. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1958.) [119

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Commonwealth of Australia. Ninth Annual Report of the Commonwealth Scientific and Industrial Research Organization for year 1956–57. Pp. 179. (Canberra: Government Printer, 1957.) 10*s*. 6*d*. [119

Tanganyika: Department of Geological Survey. Annual Report of the Geological Survey Department 1957. Pp. i+18. Shs. 2/50. Short Paper No. 24: Geology and Gold Deposits of the Ruvu River Area. By Dr. B. N. Temperley. Pp. iv+37+7 plates. Shs. 10. Map 1118: Nachingwea (Ruponda). (Dar-es-Salaam: Government Printer, 1957 and 1958.) [119

World Health Organization. Monograph Series No. 38: Insecticide Resistance in Arthropods. By Dr. A. W. A. Brown. Pp. 240. 15 Swiss francs; 25*s*.; 5 dollars. International Standards for Drinking Water. Pp. 152. 12 Swiss francs; 20*s*.; 4 dollars. Publications of the World Health Organization 1947–1957: a Bibliography. Pp. 128. 10 Swiss francs; 17*s*. 6*d*.; 3.25 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1958.) [119

Canada. Department of Mines and Technical Surveys. Geological Survey of Canada. Memoir 295: Carboniferous Stratigraphy and Rugose Coral Faunas of Northeastern British Columbia. By P. K. Sutherland. Pp. vi+177 (33 plates). 2 dollars. Bulletin 39: Soil Analyses as a Method of Geochemical Prospecting in Keno Hill-Galena Hill Area, Yukon Territory. By Robert W. Boyle and C. Brian Cragg. Pp. v+27. 50 cents. (Ottawa: Queen's Printer, 1957 and 1958.) [119

History of Botanical Researches in India, Burma and Ceylon. By Prof. S. N. Das Gupta. Part 1: Mycology and Plant Pathology. Pp. iv+118. (Madras: Indian Botanical Society, 1958.) Rs. 5.00. [119

European Productivity Agency of the Organization for European Economic Co-operation. Control of Diseases in Cattle and Sheep at Pasture. (Project No. 204.) Pp. 160. 550 French francs; 9*s*.; 1.50 dollars. Farm Management: Manual on the Preparation of National and Regional Handbooks for Use in Farm Management Advisory Work. (Project 305/1.) Pp. 156. 650 French francs; 10*s*. 6*d*.; 2 dollars. Marketing and Distribution of Meat and Dairy Products in the United States: Report of a Mission to the United States sponsored by the European Productivity Agency under Project No. 285/2. Pp. 114. 400 French francs; 6*s*. 6*d*.; 1.25 dollars. (Paris: European Productivity Agency of the Organization for European Economic Co-operation; London: H.M. Stationery Office, 1958.) [119

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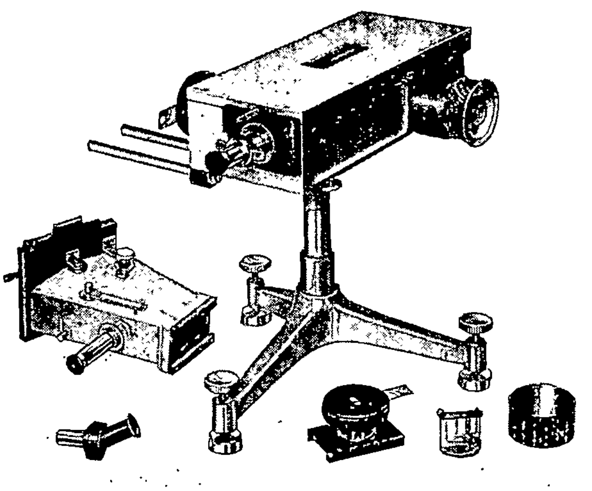

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SCIENTIFIC AND INDUSTRIAL RESEARCH: THE STATE AND INDUSTRY

IN an earlier article (*Nature*, October 25, p. 1111), a general indication was given of the activities of the Department of Scientific and Industrial Research, and the relations of the Department with other government departments interested in aspects of scientific and industrial research were discussed. We now come to consider the relations of the Department's work with the research associations and industry, in the light of the comments made in the fifth report for the session 1957–58 of the Select Committee on Estimates*.

The Estimates Committee confines its criticism to two aspects: information services and financial recoveries from industry. While in general it is satisfied that the proportion of effort devoted to information services, at present about a quarter of the work of all the establishments, is a reasonable one and likely to achieve good results, it found two weaknesses. Stressing the importance of an individual approach under modern conditions, it believes it is a mistake not to approach individual firms which might be expected to be interested in particular results, and recommends that officers of establishments should be encouraged to write to, and to visit personally, individual firms or associations representing a particular industry likely to be interested in any results achieved by the establishments. Secondly, it regards some of the publications of the establishments as too general or nebulous in character· Unless a publication is of obvious direct and specific interest, it has little chance of attracting attention, and it may even tend to discourage the reading of the Department's publications generally. The sound suggestion is made that, before embarking on any publication of its own, the Department should be perfectly clear as to who it wishes to interest by the information to be given, and design the publication accordingly.

Beyond this estimate that the Department as a whole is spending something of the order of £1–£1·25 million on information services, the report gives no indication of the actual expenditure on the Headquarters Information Division, and some of the activities of the latter which have been freely criticized by information officers and librarians escape notice. Nor is there any recognition in this report of the importance of the way in which such information services are geared to the national system of library and information services. Their efficiency depends very largely, in fact, on the way in which Government policy and practice maintain an adequate national system. A National Science Centre, a National Lending Library for Science and Technology and a National Reference Library in that field, as well as an adequate regional system, are vital factors, and appear to have been completely overlooked by the Select Committee.

As regards the financial recoveries by the establishments for work done for industry, the Select Committee on Estimates recognizes that these necessarily vary widely with different conditions, from 95·4 per cent for the Fire Research Station, which is a joint enterprise between the Department and the Fire Offices Committee, which bears half the cost of the Station, to as little as 0·3 per cent for the Radio Research Laboratory, which works mainly for Government departments. Any increased rate of recovery for this Laboratory, the Pest Infestation Laboratory, the Road Research Laboratory and the Water Pollution Research Laboratory accordingly is likely to be at the expense of another Government department; nor does the new work of the Fuel Research Station promise to offer much opportunity for recovering any substantial part of the cost, in any event for the present. On the other hand, the Committee considers that the recovery rates of the Food Investigation Organization (3·4 per cent), the Mechanical Engineering Research Laboratory (5·9 per cent) and the Building Research Station (6·5 per cent) are much too low. It regards the new scales of charges to industry which the Department has recently prescribed for the three stations as satisfactory and likely to lead to some improvement in the rate of recovery; but it recommends that all three stations should approach the question with greater determination to achieve the best possible rate consistent with departmental policy, and in particular that the Building Research Station should take account of the benefits which a supplying industry may receive when research connected with its products is successfully undertaken.

One further recommendation in this context is prompted by the measurements which the Building Research Station is making of the effect on the Bakerloo tunnel of removing and replacing the earth cover while the new Shell building in London is being constructed. This work is of great value to the Department in connexion with its study on tunnels and also to the Shell Co., in that it is helping to reduce the risk of damage to the tunnel. The Estimates Committee recommends that in future, where it seems possible that any work carried out by the Department for its own purposes may incidentally result in direct advantage to an individual firm, an agreement should be negotiated with the firm concerned before the work is started, whereby the firm should pay a direct contribution to the costs, if in fact the firm obtains a direct advantage as a result of the work.

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* Fifth Report from the Select Committee on Estimates together with part of the Minutes of the Evidence taken before Sub-Committee B and Appendices, Session 1957–58—The Department of Scientific and Industrial Research. Pp. xvi+165. (London: H.M. Stationery Office, 1958.) 9s. net.

These recommendations of the Estimates Committee, and those already mentioned (*Nature*, October 25) in dealing with the relation of the Department of Scientific and Industrial Research with other Government Departments, have far-reaching implications which are not discussed in the report, and it seems doubtful whether the Committee fully appreciates the import of some of its proposals. It is at least arguable whether the Committee's approach to the whole question of receipts for work done by the Department is sound. It seems to ignore the question of national advantage, and to overlook the fact that research is a resource and not simply an investment. The returns, moreover, are not to be reckoned in financial terms, and while, on the evidence submitted to the Committee, it is probable that some of the establishments of the Department might make firmer efforts to secure some greater return when work has been carried out for the benefit of a particular institution, firm or department, it is at least dubious whether that should be a prime consideration in research policy.

In the first place, the instructions recommended by the Committee are likely to lead to unnecessary delay in carrying out a research programme which the Department wishes to implement for its own purposes ; agreements are unlikely to be negotiated readily or quickly, particularly if the benefits are intangible or a long way ahead. Secondly, the outlook which the Estimates Committee seeks to foster could easily distort the balance of research carried out by the Department by encouraging concentration on *ad hoc* or sponsored investigations and inquiries rather than on the long-range investigations which should be a prime purpose in a central research organization. Apart from this, it overlooks the educational value of the Department's research stations in encouraging research in industry. Excessive concentration on the financial side could easily hinder the attempt which the Department is making to foster a spirit of research and co-operation with industry, and it also ignores the fact that the benefits which accrue from the Department's successful investigations are in fact returns to the nation as a whole and part of the justification of its investment.

The very fact that the work of the Department has been submitted to this searching inquiry by the Estimates Committee points to the need for some satisfactory means of setting forth, both to Parliament and to the general public, a clear and balanced picture of the work of the Department as a whole, and its significance both for the national economy and public welfare. For all the shrewd comments in this report, it appears to have escaped the Select Committee that this problem is still unsolved. Again, while the minutes of evidence contain much that deserves to be noted and weighed by the scientist and by those concerned with the organization of the nation's scientific and technical effort, the Estimates Committee, even when due regard is had to the limits of its terms of reference, seems to have been guided by too narrow a conception of efficiency as applied to scientific and technological effort.

The efficient use of the limited resources in Britain of scientific and technological man-power, which is the decisive factor in that effort, depends on the wise selection of objectives and, as the Estimates Committee recognizes, on the appropriate termination of projects and programmes, though this may well be less a financial or economic decision than it appears to indicate. It depends no less, however, on the ability to attract men of the highest calibre ; it also depends on the conditions under which they are required to serve, so that there is neither waste of highly trained man-power on work which could be equally well performed by less highly trained men nor uneconomic use of highly expensive equipment. Some of the Committee's recommendations seem likely to discourage recruitment of staff of the requisite calibre, and to lead to expensive equipment being insufficiently used. Certainly they are unlikely to encourage the maximum use of such equipment.

Nevertheless, the comments should prompt a further and widespread discussion of the whole structure and balance of the nation's research effort, and its disposition between Government establishments, universities and industry. It provides an opportunity which should be used by professional bodies as well as by Parliament, not merely to ensure that the administrative structure is appropriate and effective, but also that the ancillary factors contributing to the effective use of the scientific and technological effort of Britain, as well as to the efficiency with which that effort is conducted, receive adequate attention and support. It is probably at that point above all that additional financial support could bring the biggest increase in the return from the national effort in research and development at the present time. The Estimates Committee's report may well direct further attention to such matters of organization as the departmental organization of research in relation to a general or central body such as the Department of Scientific and Industrial Research ; but it is this question of the contributory factors on which attention needs to be focused.

FLUID MOTION IN NATURE

Natural Aerodynamics

By Dr. R. S. Scorer. (International Series of Monographs on Aeronautical Sciences and Space Flight. Division 2 : Aerodynamics, Vol. 1.) Pp. xi+312+22 plates. (London and New York : Pergamon Press, 1958.) 60*s*. net.

THE unusual title of this book is easily explained. Dr. Scorer writes about those motions of real fluids which arise chiefly as a result of solar heating and topography. The book is not concerned with the central problem of ordinary aerodynamics, the calculation of the forces experienced by bodies of prescribed shape moving through the air, but is an account of winds, convection currents, air waves, clouds and rain, and thus comprises a selection of topics from both dynamical and physical meteorology.

In the opening chapters, which deal with the equations of hydrodynamics and the concepts of vorticity and viscosity, the treatment might fairly be described as 'popular', in that much of the account is in plain language and no excessive demands are made upon the reader's knowledge of mathematical techniques. The later chapters, which deal with specific problems, require a firm grip of applied mathematics for their understanding; but the book is addressed more to the physicist and meteorologist than the mathematical specialist, and the author evidently has decided that for his purpose physical ideas are more important than details of mathematical manipulation. The result is an unorthodox but lively text, for Dr. Scorer never hesitates to interpose philosophical arguments whenever an opportunity presents itself.

The first six chapters summarize the equations of fluid motion, the Coriolis effect, vorticity, viscosity, boundary layers, wakes and turbulence. The discussion of such matters in about 140 pages implies considerable condensation, and at least one theorem concerning circulation is stated incorrectly in its abbreviated form (p. 59). However, the average physicist and perhaps even the specialist in fluid motion can scarcely fail to gain some new insight into the ways of fluids from a perusal of these vigorously written chapters (especially that dealing with vorticity), although there are dangers of over-simplification, as in the facile definition of turbulence as "a kind of stirring motion by which anything possessed by air is diffused" (p. 124). This section of the book is a useful introduction to a subject which tends rather easily to become a preserve of mathematicians, and it is refreshing to be reminded that at times even the hypothetical ideal fluid of the classical hydrodynamics has affinities with air and water.

The real originality of the book and, in the reviewer's opinion, its main value, lies in Chapters 7–10, which deal with matters which, for the most part, have not yet found their way into the curricula of the universities, although their importance in many fields of applied science is manifest. Natural or buoyant convection usually gets little more than a brief reference in text-books, and then on a qualitative rather than a quantitative basis. Dr. Scorer's account of convection is primarily mathematical, but the practical application is well illustrated by examples from meteorology (cumulus clouds), gliding, and the behaviour of hot plumes from industrial stacks. The chapter on air waves ranges from explosions to lee waves set up by mountains, a topic on which Dr. Scorer is especially well qualified to write. The account of the formation of clouds and of precipitation is mainly descriptive, which is to be expected in view of the varied and highly complicated physical processes involved. In the final chapter, entitled "Philosophy of Method", Dr. Scorer manages to combine an account of the methods of dimensions and of small perturbations with a frontal attack on geographers.

The book is thus an original account of some parts of mathematical physics mingled with the author's highly individualistic views on science in general. For such a wide field, the serious student may consider the treatment too superficial; the general reader, on the other hand, may be hard pressed at times to find his way through a juxtaposition of description and calculation. But Dr. Scorer has succeeded in writing a book which is often illuminating and never dull, and in its pages he has brought together much material which hitherto has existed only in scientific journals. There is nothing quite like this book in meteorological literature, and it is to be hoped that its high price will not deter those who wish to learn about the modern approach to some of the most fascinating and important problems of meteorology.

O. G. SUTTON

MULTIVARIATE ANALYSIS

An Introduction to Multivariate Statistical Analysis

By Prof. T. W. Anderson. (Wiley Publications in Mathematical Statistics.) Pp. xii+374. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 100s. net.

Some Aspects of Multivariate Analysis

By Prof. S. N. Roy. (Indian Statistical Series, No. 1.) Pp. viii+214. (New York: John Wiley and Sons, Inc.; Calcutta: Indian Statistical Institute; London: Chapman and Hall, Ltd., 1957.) 64s. net.

The Analysis of Multiple Time-Series

By M. H. Quenouille. (Griffin's Statistical Monographs and Courses, No. 1.) Pp. 105. (London: Charles Griffin and Co., Ltd., 1957.) 24s.

THESE three books do indeed possess the common property of containing subject-matter falling under the general heading of 'multivariate analysis', but they differ greatly, both in content and intent, among themselves. They are arranged, above, in order of a marked increase in specialization. Prof. Anderson's book is intended for the advanced college student, and has—among other desirable text-book features—a clear and thorough manner of exposition, examples in the text, and an ample supply of problems (but no model solutions). Prof. Roy's book describes a number of special topics in multivariate analysis to which he has applied some original ideas on the construction of tests and confidence intervals. This book is really a rather loosely connected series of monographs, technically of a rather advanced nature, requiring a good deal of previous reading for full appreciation, but yielding rewards in stimulation and interest. In the last book of the trio, Quenouille gives detailed consideration, accompanied by many numerical illustrations, to the application of more or less standard statistical techniques in one specific field—that of time series in which, at each epoch, observations are made on more than one variable.

Were it not for considerations of price, it would be expected that Prof. Anderson's would prove to be the most widely used of the three books. It provides, for the first time, a work suitable for the student wishing to obtain a sound appreciation of the whole field of multivariate analysis. Careful study of this book should leave few gaps to be filled—apart from those created by the present flow of papers on this subject. The first four chapters contain fundamental results in statistical theory, with special bias towards multiple regression, and give the reader an opportunity to become accustomed to the habitual use of matrices and the consequent slightly unfamiliar appearance of the text. The next chapters are on the generalized (Hotelling's) T^2 statistic, on the important 'classification problem' (also known as 'discriminatory analysis'), and on the (Wishart) joint distribution of variances and covariances. These are followed by an important chapter on multivariate extensions of the general linear hypothesis, or 'generalized analysis of variance', and two chapters on special applications of these results. Chapter 11 is on analysis into principal components, on the lines developed by Hotelling. Chapters 12 and 13 introduce the ideas of canonical correlations and variables, and the associated problem of finding the joint distribution of the characteristic roots of a certain matrix. There is a brief concluding chapter outlining various special topics in multivariate analysis.

Prof. Roy's book effectively takes as its starting point the latter part—Chapters 12 and 13 especially—of Prof. Anderson's book. Roy's method of test construction leads to criteria based on the greatest and the least of the characteristic roots of a certain matrix, rather than the symmetric functions of these roots which are usually encountered in the more conventional methods of approach. Roy is able to show that the tests he proposes should be reasonably sensitive, but he does not compare, directly, the powers of competing tests in any particular case. Indeed, numerical illustration is notably lacking, and even significance limits for the new criteria are not given, although some have been computed. In this book there will also be found (*a*) the construction of sets of 'simultaneous confidence intervals' for a number of parameters, with joint confidence coefficient defined as the probability that every one of the confidence intervals contains the true value of its appropriate parameter, and (*b*) analysis of multiple contingency tables (described as 'non-parametric generalizations of analysis of variance and multivariate analysis'). The omission of numerical illustration avoids directing attention, in (*a*), to the fact that the strong condition required of the confidence coefficient must often be paid for by uncomfortably wide confidence intervals. About one-third of the book is occupied by nine appendixes containing mathematical results used in the main text.

Quenouille summarizes the problems considered in his monograph as follows (slightly abbreviating the original): (1) Definition of the structure of several interdependent time series, and deduction therefrom of their properties. (2) Inference of structure from population, or from observed, correlation properties. (3) Likely errors in specification of structure, and the effects of these errors on analysis. (4) Methods of estimating values of parameters, given a particular structure, and of testing whether a particular structure is appropriate. (5) Practical application of techniques derived from study of the above problems to observed series.

The programme so specified is carried out in a competent manner. There does not seem to be any attempt to make the treatment or discussion exhaustive—for example, the work of Rudra on the problem of discriminating between rival structures in the case of univariate series is not mentioned—but the author has produced an adequate text for anyone wishing to extend a moderate knowledge of univariate time series analysis into the multivariate field. The text is written with evident regard for students' difficulties, and numerical illustration is profusely provided. The omission of any reference to periodic series and periodogram analysis is unfortunate, since it is a rather sweeping assumption to suppose that all observed series may be usefully assigned a moving average or autoregressive structure, with which the monograph is largely preoccupied. A list of symbols, with meanings, is provided. Exception can be taken to the author's statement that E is the usual symbol for the operator with the property:

$$Ex_t = x_{t-1}$$

—this operator would usually be written E^{-1}.

Both Roy's and Quenouille's works suffer from a number of small misprints, mostly in suffixes, exponents, and similar positions. They are not likely to prove misleading to the informed reader, though the occurrence of a subscript $t - 1$ instead of $t + 1$ in Quenouille's equation (5.6.1) could cause some puzzlement.

The essential qualities of the three books are, briefly: Anderson: a sound text-book of traditional style in a new field; well produced, but expensive for its size. Roy: a book for the specialist—and only for a very special kind of specialist; consolidates material at present scattered in the literature, and may stimulate some further research. Quenouille: a readable book, repaying the effort of understanding the rather unusual notation; coverage of subject rather uneven, but not unduly so for a fresh subject.

N. L. JOHNSON

EIGENFUNCTIONS

Eigenfunction Expansions Associated with Second-Order Differential Equations, Part 2

By Prof. E. C. Titchmarsh. Pp. xi+404. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 70*s*. net.

IN 1946, Prof. Titchmarsh published "Eigenfunction Expansions associated with Second-Order Differential Equations" (Oxford, at the Clarendon Press) and a photographic reprint was made in 1950. This slim and modest volume contained the results of Titchmarsh's researches from 1939 until 1945 and provided a new and original theory of this important and growing subject, which was applicable not merely to equations of the Sturm–Liouville type, but also to the singular equations studied by Weyl.

Titchmarsh's method is independent of the calculus of variations, of the theory of integral equations and of the theory of linear operators—each of which has been used as a basis of the theory of eigenfunctions of differential equations. Titchmarsh had discovered a simple and direct method of studying this subject by means of contour integration and the calculus of residues, and of proving the central expansion theorem. In the present volume this method is extended to *partial* differential equations of the form:

$$\Delta\psi + \{\lambda - q(x,y, \ldots)\}\,\psi = 0$$

where Δ is the Laplacian operator in n-dimensional Euclidean space.

The principal problems discussed are (1) the expansion of an arbitrary function in terms of the eigenfunctions of a prescribed equation, (2) the effect of small changes in the equation on the eigenvalues and eigenfunctions, (3) the nature of the spectrum and the distribution of the eigenvalues. In addition to these great questions, the author also considers a number of special problems of considerable interest, namely, the eigenvalues of separable equations, and the case in which the function $q(x,y, \ldots)$ is periodic. The final chapter deals with the analytical apparatus which has been used in the body of the work and provides proofs for the various theorems which have been required.

Many of these problems are of considerable interest to mathematical physicists, especially to those working in quantum theory, and plausible but non-rigorous treatments are well known. Titchmarsh has succeeded in giving rigorous proofs and has put all quantum theorists heavily in his debt by his careful analysis of the complex and difficult questions of eigenfunction theory. His investigations of the expansion theory, the perturbation theory and the spectral theory are each of significance for the applied mathematician and, if not every proof can be described as short and simple, they are all admirably lucid and cogent. G. TEMPLE

ELECTROCHEMISTRY

Electrochemistry

Principles and Applications. By Dr. Edmund C. Potter. Pp. xii+418. (London: Cleaver-Hume Press, Ltd., 1956.) 50s.

THE author states that his aim was to produce a concise introductory text for the technological student and the specialist electrochemist in which he would endeavour to reflect the modern emphasis on a more dynamic and mechanistic interpretation of electrolytic processes than, presumably, has hitherto been the case.

To write a book which would be of service to the beginner and the specialist alike would, indeed, be an accomplishment, and this the author has certainly not achieved. This book is more likely to be of use to the student who has already gained a grasp of the fundamentals of electrochemistry from the standard works on physical chemistry, and who wishes to acquaint himself with the industrial applications of the subject.

The mechanistic interpretation of electrolytic processes refers essentially to the interpretation of the dependence of hydrogen overpotential on current density. This has been included in text-books which have been published within the past twenty years.

Regarding the chapters dealing with fundamentals, the logical development and presentation often leave much to be desired: the English is not always good and the sentences are often involved and obscure. It is likely that the text was based on rather sketchy lecture notes, for it lacks much of that explanatory matter which a lecturer must expound but which the student may not then think it worth while to record.

The treatment of the Arrhenius, activity and Debye and Hückel theories is so cursory that a student would not be able to glean anything very substantial from it. Throughout, the term 'activity' is applied to ions, but the author does not indicate that the activity theory has only been satisfactorily applied to the electrolytes contained in 'cells without transport'. One such cell is described, but advantage was not taken to show how it might be used to determine experimentally the mean ionic activity of an electrolyte, for example, $a_{\pm HCl}$.

It is somewhat disturbing to read on p. 83 that "Nernst's original arbitrary zero of potential is that potential corresponding to the reversible equilibrium between hydrogen gas at one standard atmosphere pressure and hydrogen ions at unit activity". In 1900 Nernst stipulated that the electrode solution should contain hydrogen ions at unit concentration, and it was not until 1913 that G. N. Lewis advocated the substitution of activity for concentration. Dr. Potter does not explain that the activity of a single ion cannot be determined experimentally and that it is necessary to assume that, for example, for hydrochloric acid, $a_{\pm HCl}$, is equal to a_H. Instead, he merely states that "If the electrolyte used is hydrochloric acid a strength of approximately 1·2 *N* at 25° C. corresponds to unit activity of hydrogen ions", and he gives no clue how such a concentration has been experimentally ascertained.

The misuse of the terms 'strength', 'strong' and 'weak' in referring to solutions and current is to be deplored, for chemistry teachers have, for many years past, been deprecating the use of 'strength' as being synonymous with 'concentration', and 'current' (a rate) as being synonymous with 'electricity' (a quantity). Such phrases as "electric current flows" (p. 1) and "passage of current for 1 second" are particularly objectionable. Many of the conductometric titration curves depicted are defective, and especially that for phosphoric acid. In defining 'acids' and 'bases' in terms of the Lowry–Brønsted theory, 'hydrogen ions' should read 'protons'. The method of deriving expressions for electrode potentials can scarcely be adapted to the electrodes in a cell with transport.

Though by no means a complete survey of electrochemistry, the last half of the book is obviously that part of the subject with which the author is more intimately conversant and it brings together a good deal of useful material. H. T. S. BRITTON

NEOMYCIN

Neomycin

Its Nature and Practical Application. Edited by Selman A. Waksman. Pp. x+412. (London: Baillière, Tindall and Cox, Ltd., 1958. Published for the Institute of Microbiology, Rutgers University.) 40s.

THE comprehensive screening programme to which the Actinomycetes, and in particular the members of the genus *Streptomyces*, have been subjected in various laboratories has provided many new antibiotics, a number of which are of value in chemotherapy. As a result of such a programme, Waksman and Lechevalier in 1949 announced the discovery of a new basic antibiotic which was named 'neomycin'. It was active against bacteria resistant to streptomycin, including tuberculosis organisms. It was thought that the new antibiotic might have all the desirable properties of streptomycin without its disadvantages, and that it could find an important place in tuberculosis therapy. Unfortunately, the high hopes at first entertained of neomycin were not fulfilled in practice, since clinical trials showed that when administered parenterally it had an irreversible injurious effect on the auditory system. Neomycin has, however, gradually established itself, in spite of its limitations, as a useful antibiotic and indeed the drug of choice in certain infections.

As commercially prepared, neomycin is a mixture of two isomeric compounds, neomycin *B* and neomycin *C*, in which the former predominates. Although the molecular structure of neomycin is not yet completely established, sufficient is known to place it as closely related to streptomycin, from which, however, it differs considerably in biological properties. It has a wider antibacterial spectrum than any other antibiotic, is rapid in action, shows little tendency to produce resistant organisms and rarely produces hypersensitivity in the patient. Its disadvantages, the tendency to produce deafness and renal damage, are only evident when it is administered parenterally. It is one of the best antibiotics for local use and as an intestinal antiseptic by the oral route since it is not readily absorbed from the bowel.

The present work, appropriately under the editorship of Dr. Selman A. Waksman, offers a timely account of the information at present available, mainly from American sources, concerning the nature, microbiological aspects, pharmacological properties, and clinical and veterinary uses of neomycin. It is a compilation resulting from a co-operative effort to assemble between the covers of one volume the knowledge and experience of a number of investigators from different centres in the United States. Each chapter is written by one or more of these contributors, but due, no doubt, to careful planning and skilled editing there is little overlap, and the result is a balanced and most readable account of the present state of knowledge on the subject of neomycin, which could hitherto be assessed only by tedious search of the literature.

There is an excellent bibliography in which the references are sensibly collected together instead of being distributed at the end of each chapter (apart from a few supplementaries). Appendixes summarize the specific clinical uses of neomycin and list the preparations containing neomycin with their trade names and indications, compiled from information supplied by the various manufacturing companies, the names and addresses of which are given. This list may serve to correct the impression, which might otherwise be gained from reading the book, that streptomycin is of little interest outside the United States, since the number of foreign manufacturers cited is nearly twice that of firms located in the United States. J. H. Birkinshaw

A THERMOPHILOUS SHRIMP FROM TUNISIA

Anatomie und Histologie von *Thermosbaena mirabilis*
Ein Beitrag zur Phylogenie der Reihe Pancarida (Thermosbaenacea). By Dr. Rolf Siewing. 1958. *Akademie der Wissenschaften und der Literatur. Abh. Math.-Naturw. Kl. Jahrgang* 1957, No. 7: 197–270, 43 text-figs.

Dr. Siewing's recent admirable studies on the comparative morphology of the Crustacea Malacostraca have been widely acclaimed and no one is better qualified than he to elucidate the anatomy and histology of *Thermosbaena mirabilis* Monod. This minute crustacean, first described in 1924, is restricted in its distribution to a few baths, fed by hot springs, at El Hamma, Tunisia. In recent years three subterranean species, belonging to the closely related genus *Monodella*, have been found in Italy and Yugoslavia. These four species, measuring 1·5–4 mm. in length, are unique among Malacostraca in having a dorsal brood chamber formed by a temporary enlargement of the carapace. Opinion has varied as to the systematic position of the order Thermosbaenacea; it is sometimes referred to the division Peracarida, or placed between the Peracarida and the Syncarida; Sars united it with the Bathynellacea in a new group, the Anomostraca.

The material studied was collected by Dr. Anton Brunn in 1938. A detailed account, accompanied by admirably clear line drawings and microphotographs, is given of each system in turn—vascular, respiratory, nervous, digestive and reproductive. The reconstructions of the general anatomy of male and female are excellent, although an enlargement of the head end of Fig. 1, *A*, with its numerous guide lines, might with advantage have been included. Anatomical peculiarities are fewer than might have been expected. The oviduct opens in the usual Malacostracan position, at the base of the sixth thoracic limb, and there is no dorsally directed branch such as has been claimed for *Monodella* but not confirmed. Prof. Barker, who collected ovigerous females in September 1950, thinks that during oviposition *Thermosbaena* lies on its back so that the few large eggs drop into the brood chamber (personal communication). A pair of reduced, though possibly still functional, eyes has been found. Certain features appear to be adaptive, since they are paralleled in other minute cavernicolous or interstitial forms. For example, the extremely short heart is restricted to the first thoracic segment, where it is in intimate association with the respiratory carapace; in the Bathynellacea, which have no carapace, it lies in the fourth thoracic segment.

An appraisal of the external morphology follows. At times the author is prolix; for example, his interesting point about the segmentation of the thoracic limbs could have been made in a few paragraphs instead of in a few pages. In the second pair, which are set quite differently on the body and are apparently modified as gnathopods, the ischium has fused completely with the basis. In each of the succeeding limbs (peraeopods) it has almost completely fused with the merus. He concludes that the Thermosbaenacea, though closely related to, must be excluded from, the Peracarida. I am not entirely convinced of the necessity for the new division Pancarida, which is based chiefly on two characters: the structure of the maxillipeds and the dorsal brood chamber. The retention of two endites and the persistence, in some species of *Monodella*, of exopodite and/or endopodite in the maxilliped suggest, he says, a very primitive position for the Thermosbaenacea. This condition is widespread in the Decapoda and—the coxal endite apart—in Mysidacea. In *Monodella*, when both rami persist the maxilliped exhibits marked sexual dimorphism, the endopodite being modified to form a clasping organ in the adult male. As to the brood chamber: within the Copepoda certain parasitic forms have abandoned the normal method of carrying the eggs in favour of a carapacial brood chamber, and this has probably occurred independently more than once. Why then is the author so certain that something analogous could not have happened within the Peracarida (pp. 261–263)? There might be some good reason why, in a minute animal adapted to an extreme biotope, a ventral marsupium composed of oostegites became impracticable (for example, the thoracic limbs might be too short). Owing to the high temperature to which *Thermosbaena* has become adapted (around 45° C.) its feeding and locomotor habits would have to be studied in the field. This could only be undertaken by a competent observer who, from previous experience with other minute crustaceans, knew exactly which methods to adopt.

Whether one accepts his conclusions or not, Dr. Siewing is to be congratulated on another excellent piece of research. Isabella Gordon

Geophysics and the IGY

Proceedings of the Symposium at the Opening of the International Geophysical Year. Conducted by the United States National Committee for the International Geophysical Year, National Academy of Sciences, Washington, D.C., June 28–29, 1957. Edited by Hugh Odishaw and Stanley Ruttenberg. Pp. iv+210. (Geophysical Monograph No. 2.) (Washington, D.C.: American Geophysical Union of the National Academy of Sciences—National Research Council, 1958.) 8 dollars.

In the whole of the programme for the International Geophysical Year nothing has captured the popular imagination more than the attempts to explore the upper atmosphere. It is likely that the layman does not entirely appreciate the scientific significance of all the *Sputniks* and 'Black Knights' that leave the surface of the Earth; but he is certainly made more aware of this aspect of the International Geophysical Year, via the writings in the press, than of any other; and, in a way, so it is for the geophysicist.

Almost three-quarters of the space available in this monograph on the International Geophysical Year is devoted to the physics of the upper atmosphere. Eighteen papers cover most aspects of this science from 'whistler' (audio-frequency radio waves arising from lightning discharges) studies to auroræ observations; and, of these, five concern the use of rockets and satellites in this high-atmosphere work. The papers in this section which are of most interest to the general scientists are probably those dealing with the observations to be made on the geomagnetic field. A detailed knowledge of the Earth's magnetic field is of practical importance in many forms of science and their related applications, from ionospheric and auroral physics to navigation and mineral exploration.

There are twelve papers in the more solid side of geophysics: that is, the lower atmosphere and the Earth itself. These deal with meteorological and oceanographic studies, the polar work that has been and will be performed, and with information concerning the shape, crust, and mantle of the Earth via gravitational and seismological measurements.

This book is the outcome of a symposium held last year before the main programme began. As such, of course, much of the information contained in it is conjectural and, at this stage, out of date. However, it is worthy of consideration by anyone interested in the doings of the International Geophysical Year.

D. Taylor Smith

Quantitative Organic Analysis

By James S. Fritz and George S. Hammond. Pp. xiv+303. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 52*s*. net.

The contents of this book are more accurately described by a subtitle ("The Use of Fundamental Principles for Solving Problems in Organic Analysis") than by its main title. The latter would lead one to expect the book to start with the usual description of elemental analysis, but this comes nearly half-way through. Instead, the opening chapter is an interesting discussion of the difficulties arising in the determination of carbonyl groups by oximation, which is taken as an illustration of the problems encountered in devising schemes for determining functional groups in general.

Other chapters deal with acid–base titrations in non-aqueous solvents, indirect acid–base methods, oxidative and reductive methods, manometric methods, metal ion complexes, kinetics in analysis, spectrophotometric methods, separations, and physical and polarographic methods. Finally, there are useful hints on solving new problems and details for certain standard procedures, such as determination of hydroxyl groups by acetylation, saponification of esters, and determination of sulphur, of unsaturation by bromination, and of peroxides.

This is not a text-book in the ordinary sense; rather does it discuss the underlying principles of various methods and their advantages and limitations. Although it mentions many applications, experimental details are usually rather too brief for practical purposes. For example, the ordinary 'combustion' method is described, but the diagram of the tube gives no indication of the dimensions in spite of the mention of the 'micro-scale'; and the statement that "Glucose has been determined by oxidation with iodine to gluconic acid" gives no hint of the effect of such factors as alkalinity, concentration and time. Also, under distillation, theoretical plates are mentioned but not defined. The section on chromatography is not up to date, and too cursory.

In spite of these few minor blemishes (and of the spelling of Tollens without his 's'), the book is well worth reading, for it is clearly written and gives a fascinating review of the great diversity in analytical methods now available to the organic chemist; moreover, it is very well produced.

A. D. Mitchell

Dynamic Programming

By Richard Bellman. Pp. xxv+342. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1957.) 42*s*. net.

Many will have had glimpses over recent years of the work of R. Bellman in the field of multi-stage decision processes. Gradually, a body of concepts and methods has emerged for treating the many real problems that arise in this field. The developments to date have been collected and presented in the book under review, which is a Rand Corporation Research Study. The author begins with a chapter entitled "A Multi-Stage Allocation Process". This explains the type of practical situation to which the theory of dynamic programming relates and introduces the reader to the methods of solution. The next chapter adds a stochastic element to the problem of decision on a multi-stage process. The mathematical technique is developed in the next two chapters, and then follow three chapters on inventory and bottleneck problems. A chapter on multi-stage games is followed by a final chapter on Markovian decision processes.

This book, while very well written, is definitely an advanced text for the mathematician who is interested in the development and application of mathematical methods in management science, including econometrics. It will not be understood by most managers, but this may well be the result of our present social organization rather than a reflexion upon the author. It is not, after all, possible to convey highly technical concepts in a language that everyone can understand. The present book is an excellent example of the way in which mathematics is finding new domains of application, and for the first time clears the way for logical analysis of some time-worn riddles faced by business men. L. S. Goddard

CYTOPLASM IN SEXUAL REPRODUCTION

By PROF. KENNETH MATHER, C.B.E., F.R.S., and DR. JOHN L. JINKS

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GENETICAL studies have displayed the cytoplasm as playing but a minor part in the determination of differences among individual plants and animals produced by the sexual process. Evidently the cytoplasm handed on by a mother to her sexual offspring must be closely similar to that which she herself received from her parents in respect of any essential determinants of cell character and development. At the same time, there is every reason to believe that differentiation within an individual depends characteristically on change of the cytoplasm[1-3]. Thus, either the cell-lineage connecting the original zygotic cell of the individual with the egg it ultimately produces must be exceptional in involving no change of cytoplasmic type, or its cytoplasmic progression must come full circle within the individual, the end-point being the same as the beginning[1]. In higher animals there is no simple breeding test available for investigating the progression of a cell-lineage, of recognizing and separating progressive changes in nucleus and cytoplasm, by simple breeding; and even in higher plants this approach has yet to be put to successful use. Experimental intervention by the transfer of nuclei from cells at one stage to the cytoplasm of cells at another has been successfully practised and has yielded valuable results[4,5]. The implications of these findings are, however, as yet by no means fully clear[3], and in any event this technique is so demanding as to place sharp limitations on its use.

Micro-organisms present more tractable material, and the filamentous fungi in particular offer a certain, if limited, range of differentiation combined with the opportunity to propagate and breed from several types of cell in such a way that changes of the cytoplasm and nucleus can not only be detected but also distinguished from one another by reassociation of these cell parts. Thus, *Aspergillus glaucus*, for example, can readily be propagated in three ways: from the tips of the hyphæ, from the single-celled asexual spores termed conidia, and from the sexually produced ascospores. Propagation by any of these means produces an individual potentially capable of displaying the complete range of development, so that its capabilities may be fully observed and change from those of its parent recorded. Furthermore, the occurrence of anastomoses between hyphæ of different individuals, and the heterokaryosis to which this prospectively leads, allow of the bringing together of unlike cytoplasms as well as nuclei within a single individual, and of their sorting out and reassociation in both the conidia and the ascospores which that individual produces. Indeed, the conidia are especially valuable in distinguishing cytoplasmic from nuclear differences, for the nuclei of a heterokaryon normally sort out as units in the production of its conidia, without any of the genic recombination seen in ascospores. Thus, each kind of nucleus can be marked and followed unambiguously in conidial production by a single mutant gene.

Making use of these properties of the fungus, Jinks has been able to show not only that differentiation and ageing of the cells involve characteristic changes of the cytoplasm[6], but also that selection can be used to produce changes of character which spring wholly from alterations in cytoplasmic content[7]. Certain of these changes depend on differences among cells of like status, as where a sample of conidia from an individual produce offspring differing in their rates of growth so that selection may be practised among them. Others, however, appear to depend on cytoplasmic differences arising as part of the process of differentiation. Thus, if propagation is continued for several generations by conidia, the production of perithecia and ascospores gradually falls until the fungus at length loses its capacity for sexual reproduction and becomes imperfect[8]. If propagation is continually by hyphal tips, the capacity for sexual reproduction is similarly lost, but so later is that for the production of conidia also. This has also been observed in *Neurospora*[9]. Similar changes can, of course, come about by the change of nuclear genes within an individual; but these are spasmodic and show all the unpredictability of gene mutation, whereas the cytoplasmic alterations appear as characteristic of the normal processes of differentiation and development.

So far, these changes have shown us no more than the negative side of differentiation, for they all depend on the loss of a capacity which is no longer being used and which is therefore no longer of importance to the plant. If propagation is wholly by conidia, the production of sexual structures is of no significance and its loss of no disadvantage. Indeed, its retention could be actively disadvantageous by the profitless consumption of nutrients and metabolic materials capable of more useful deployment elsewhere, and it is thus no surprise to find conidial production rising at first as that of ascospores declines. But hyphæ must obviously continue to be produced, as they are a necessary link between parent and daughter conidia. Where, on the other hand, propagation is wholly by hyphæ, neither conidium nor ascospore takes any obvious role in the cycle, so that both may be lost with impunity, at least in the short term. It would thus appear that only capacities essential to the operative reproductive cycle are retained, the cytoplasm changing so as to lose the ability for sustaining types of development no longer of significance to the plant.

When, however, we turn to the sexual cycle a different picture emerges. With continued sexual propagation, the production of conidia is of no more importance than was that of ascospores with conidial propagation—yet conidia are never lost as a result of sexual propagation, nor indeed is the frequency of their production reduced in any way so far as can be seen. In contrast to the asexual, therefore, the sexual cycle maintains in the cytoplasm the full range of developmental capacities even where these are no longer of significance. Furthermore, this does not merely reflect an absence of cytoplasmic change in the cell lineage connecting parent ascospore and daughter, as we can see if we go back to lines the

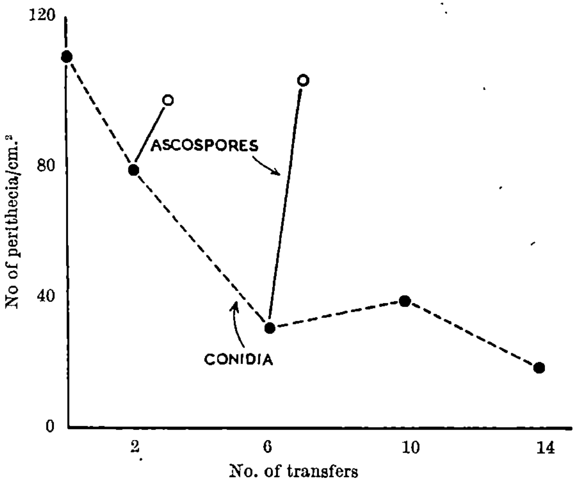

Fig. 1. The effects of propagation by conidia and by ascospores on the frequency of perithecial production in *Aspergillus glaucus*. Continued propagation by conidia (dotted line) results in a gradual decline of perithecial production. This is, however, immediately restored to its original level by a single propagation through an ascospore

sexual capacity of which has been reduced by conidial propagation. This reduction is gradual, but no matter how far it has gone, so long as any ascospore remains to be taken, the plant can be restored to complete, or virtually complete, sexuality by a single propagation through an ascospore (Fig. 1). Whether sexuality could be so restored to a plant which has completely lost its capacity for sexual reproduction is, of course, an unanswerable question since the necessary ascospore is not produced.

Thus, where a number of conidial propagations are interposed in the lineage between parent and daughter ascospores, the cytoplasm demonstrably changes in its determination of sexual capacity. It is, nevertheless, restored to its original state by the single propagation through the final ascospore. Evidently the process of sexual reproduction involves an active and positive re-adjustment of the cytoplasm, a 'spring-cleaning' or 're-tailoring', so that despite the alterations the standard basic cytoplasmic pattern is once again restored. There has been a cytoplasmic progression during the time of asexual propagation, but it is brought full circle during the process of sexual reproduction.

A further consequence of this re-standardizing effect of sexual reproduction on the cytoplasm is seen when the variation between individuals arising from ascospores is compared with that between individuals from the conidia of the same parent plant. Where the parent is a heterokaryon, genic segregation and recombination will occur in its sexual offspring. Their variation may thus be greater than that of conidial offspring, in the production of which only sorting-out of whole nuclei can occur. But if the parent is a homokaryon, carrying only one genetical type of nucleus, genically determined variation must be absent from all the offspring, whether sexual or asexual, and can indeed be shown to be absent by suitable tests. The variation is then found to be much greater among the conidial than among the sexual progeny (Fig. 2). In other words, the cytoplasm is more variable between the conidia than between the ascospores. Again we are seeing the standardizing effect of sexual reproduction on the cytoplasm.

Comparison of the effects of propagation by ascospores and conidia indicates an active re-standardization of the cytoplasm during the sexual process, though, of course, it does not tell us precisely where in the sexual cycle this occurs; further observation will be needed for that. Comparison of the effects of propagation by conidia and hyphal tips suggests that some readjustment of the cytoplasm may take place during conidial production, though it must obviously be less comprehensive and precise than that occurring in the sexual cycle. Continued propagation by hyphal tips results first in the decrease and loss of ascospore production, then in the decrease and loss of conidial production, and finally in a progressive difficulty even of the hyphæ to maintain full growth. So long, however, as conidia are produced the intervention of a conidial propagation will at least partly restore the capacity for conidial production, and it will improve hyphal growth itself. Furthermore, certain cytoplasmic adaptations, as for example to tolerance of mercuric chloride in the medium, though regularly transmitted via the hyphæ, are passed on much less regularly through conidia[10], and not at all through ascospores. Thus, the process of cytoplasmic re-standardization, though shown most characteristically and precisely by the sexual cycle, may not be confined to it.

Should sexual reproduction always involve a standardizing or cleaning of the cytoplasm, as it appears to do in *Aspergillus glaucus*, the cause of the cytoplasm's apparent inertness in hereditary transmission, as displayed by genetical experiments, would be clear. There is, however, as yet, little evidence from higher plants and animals to show whether such a process occurs or not. With some exceptions, chiefly in the Leguminoseae, plant virus infections are not transmitted through the seed. This suggests that the cytoplasm may be actively readjusted during egg-production, though the evidence cannot be regarded as compelling before it has been shown that the virus does actually enter the cell-lineages of the growing points from which the eggs are ultimately produced. We know also that the side-shoots of some plants show a type of growth different from that of the main shoot when both are taken as cuttings[11]. It would be of great interest to know how the two types behave in subsequent

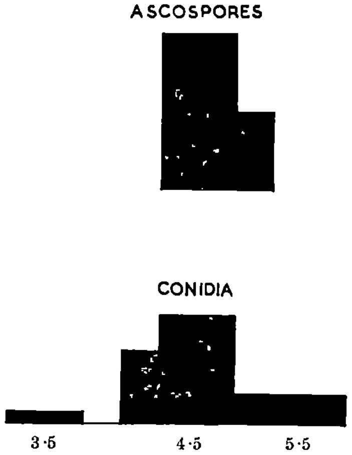

Fig. 2. Histograms to show the frequencies of colonies with different rates of growth among (above) the sexual and (below) the conidial progeny of a homokaryon of *Aspergillus glaucus*. The conidial progeny are more variable

breeding. In this way it would be possible to show first whether the difference itself involved nuclear change, and given that it did not, whether the cytoplasmic difference was abolished during sexual reproduction. By analogy with *Aspergillus*, we should expect the sexual offspring of both types of cutting to be like the original plant from which the cuttings were taken. There is evidence that the cytoplasm of parthenogenetic eggs in Rotifers can change with the age of the mother[12], and even that the cytoplasm can vary in the eggs of *Drosophila melanogaster*[13]; but the variation in the flies appears to be trivial, and in any event a relation to ageing does not preclude the occurrence of a process such as that detected in the fungus, since ageing of the egg could follow on a standardization of the cytoplasm during its initiation. In man, fraternal twins may be quantitatively more alike at birth than identicals. This can be interpreted as indicating that the cytoplasms of separately produced eggs are more alike than those of two totipotent cells produced from the division of a single egg[14], as might be expected if a process of cytoplasmic re-standardization occurs during human sexual reproduction.

Where, as in *Aspergillus*, a process of cytoplasmic standardization occurs as a regular feature of sexual reproduction, a remarkable comparison appears between nucleus and cytoplasm. Sexual reproduction is the time of nuclear variation, springing from recombination of the genes. Somatic development, on the other hand, is relatively a time of nuclear stability, for although nuclei may show changes during development, these are secondary and not the prime cause of differentiation. With the cytoplasm the situation is reversed. Somatic development and differentiation depends characteristically on cytoplasmic change, while sexual reproduction is the time of cytoplasmic stabilization or standardization. Sexual reproduction would then be providing not only the familiar means of achieving that redistribution of genes upon which adaptation ultimately depends, but also the means of supplying each new individual with a precisely adjusted cytoplasm in which those genes can successfully do their work of guiding its differentiation and development.

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LOCALIZATION OF INTERACTION SITES IN MULTI-COMPONENT TRANSFER SYSTEMS: THEOREMS DERIVED FROM ANALOGUES

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AND

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A STRIKING phenomenon of electron transfer in oxidative phosphorylation systems is the change in the steady-state oxidation-reduction levels of the respiratory carriers in response to changes in the concentration of phosphate or phosphate acceptor[1]. When, in an adjacent pair of carriers, one component is observed to become more oxidized and the other more reduced, a crossover point is identified[2-3]. Depending upon the experimental conditions, three such points can be observed in the respiratory chain of mitochondria: between reduced pyridine nucleotide and flavoprotein, between cytochromes *b* and *c*, and between cytochromes *c* and *a*[1]. It has been of great importance to determine what relationship may exist between the position of these crossover points and the sites at which the chemical reactions occur that lead to energy conservation and finally to the phosphorylation of adenosine diphosphate.

Isolation of portions of the respiratory chain has not succeeded in identifying the location of sites of energy conservation because of the difficulty of isolating components of the chain[4], the loss of phosphorylative activity upon isolation[5], and the demonstrated changes in the pathways of electron transfer that may arise upon chemical fractionation of the components[6-8]. Thus, fractionation and reconstitution cannot yet be used for final proof of conclusions that are drawn from physical-chemical studies of the phosphorylative process.

At present, it is necessary to deduce the location of sites of energy conservation from a consideration of the response of a chain of electron-transferring enzymes to the presence or absence of an inhibitor that can act simultaneously at several sites in the chain. Such a multi-component system is difficult to comprehend without the derivation of general theorems concerning the response of such systems by mathematical procedures and by observations of the response of model systems or of analogue-computer representations of various mechanisms.

All phenomena associated with cross-over behaviour were first observed in direct studies of the respiratory enzymes of mitochondria, during which it became apparent that certain rules permitting the localization of phosphorylation sites might apply. The cross-over

Table 1. CROSS-OVER BEHAVIOUR OF THE CHEMICAL SYSTEM: CHANGES OF STEADY-STATE LEVEL CAUSED BY A DECREASE OF FLUX RESULTING FROM EXHAUSTION OF ADENOSINE DIPHOSPHATE

Key: − corresponds to a reduction, + to an oxidation, 0 to no observable change

Material	Source	Substrate	Inhibitor	Temp. (° C.)	Reference	$S\to$ RPN $\to$	$fp \to$	$b \to$	$c_1+c \to$	$a \to$	$a_3 \to O_2$
Mitochondria	Rat liver	β-Hydroxybutyrate	None	26	1	−	−	−	−	+	+
	,,	,,	Azide	2	12	−	−	−	+	+	+
	,,	,,	None	26	Exp. 377	−	+	−	−	+	
	,,	,,	,,	38	15	−	+	−			
	Guinea pig liver	Succinate	,,	26	Exp. 376b	−	−	−	−	+	
	,,	,,	Azide	,,	Exp. 384	−	+	0	+	+	
	,,	Glutamate	None	,,	1, Exp. 372	−	−	−	+	+	+
	,,	,,	,,	,,	Exp. 376b	−	+	−	+	+	
	,,	,,	Azide	,,	Exp. 384	−	+	0	+	+	+
	Locust flight muscle	α-Glycerol phosphate	None	20	16	−	−	−	−	+	
Intact cells	Yeast	Ethanol	None	26	17	−	−	−	−	+	+
	,,	,,	Azide	,,	Exp. 543			−	+	+	
	Ehrlich ascites tumour	Glucose	None	,,	18	−		−	−	+	
	Frog sartorius muscle	,,	,,	,,	19, 20	−		−	−	+	
	,,	,,	Azide	,,	19			0	+	+	+
	Toad heart muscle	,,	None	,,	21	−	−	−	+	+	

behaviour of the chemical system has stimulated a number of studies to demonstrate generalities relating interaction sites to cross-over behaviour. The first study was made with an electronic analogue computer representative of the chemical system that operates in accordance with the law of mass action[2] and has led to some general rules summarized here. These rules, in their more elementary form[2], stimulated a mathematical approach involving inequalities applicable to many other types of mechanism[3]; this approach is presented in detail in another paper[9]. Holton[10 11] has recently used a current-flow network to demonstrate that interaction in physical as well as chemical systems can be located by the cross-over generalities given here. The more general applicability of these ideas justifies their detailed description.

Responses of the Respiratory Chain

Since spectroscopic observations of the response to adenosine diphosphate of isolated mitochondria and of mitochondria in intact cells and tissues are now extensive, a summary is appropriate (Table 1). In the course of these studies it was found that the appearance of a cross-over point depends, in specific cases, upon the balance of dehydrogenase and oxidase activities and, in general, upon relative values of reaction velocity constants for the interaction of the components of the respiratory chain. These velocity constants are affected by many factors, particularly the source of the mitochondria, the nature of the substrate, the presence of inhibitors, and the temperature. So that the data will conform with the results obtained from analogues discussed in the following paragraph, the responses are tabulated for decreases of flux caused by the exhaustion of adenosine diphosphate. A minus sign corresponds to a reduction, a plus sign to an oxidation, and a zero to no observable change (presumably the result of a balance of oxidizing and reducing tendencies). From the data of Table 1, we draw the following generalizations. (1) Only minus signs are observed for reduced pyridine nucleotide, and only plus signs are observed for cytochromes a and a_3 in isolated mitochondria. (2) The other components may show minuses, pluses, or zeros, depending upon the conditions. (3) Cross-over points (− to +, going from substrate to oxygen (see below)) localize interaction sites between reduced pyridine nucleotide and flavoprotein, b and $c + c_1$, and $c + c_1$ and a. Reversed cross-over points (+ to − (see below)) are found between flavoprotein and b. Since the resolution of the spectroscopic method is insufficient to distinguish accurately between cytochromes c and c_1, it is not known whether another cross-over point lies between these two components; however, thermodynamic considerations make this unlikely. In toad heart muscle, some preliminary evidence for a cross-over point between a_3 and oxygen has been obtained, but this is not supported by studies of the isolated toad heart mitochondria (Ramirez, J., personal communication). The three cross-over points localized thus far are consistent with the P to O value of the respiratory chain of approximately 3, although additional sites of phosphorylation are not ruled out by any existing data.

The data for intact cells, although less complete than those obtained for isolated mitochondria because of the inherent difficulties in controlling the type of substrate employed, show two of the three cross-over points observed in the isolated systems. This type of study should afford a basis for conclusions on the similarity between the phosphorylation efficiency of intact cells and that of isolated mitochondria.

Model Systems and Computers

In general, model systems are constructed for the purpose of representing a complex process on a convenient scale of size, time, etc. The model may represent accurately all the features of the original, or just some of them. In the latter case, the model may also demonstrate artefactual responses that must be carefully guarded against. The model may be constructed as an analogue of the process itself: for example, as a chemical system with simpler reactions or as an electric or hydraulic analogue where chemical concentrations are represented by voltages or liquid volume.

A more general approach is the computer solution of differential equations which represent the basic physical laws of the chemical system. This method has been used in studies of the respiratory chain and its associated phosphorylation reactions[3]. This model is based upon the assumption that the law of mass action applies to the reactions of the components of the respiratory chain[3]. On the basis of

Table 2. CROSS-OVER BEHAVIOUR OF ELECTRON-TRANSFER SYSTEM CAUSED BY DECREASES OF FLUX IN RESPONSE TO CHANGES IN INTERACTION AT THREE SITES

Enzyme concentration 10^{-6} *M*. Reaction velocity constants are specified in equations or in table in units of μmolar^{-1} sec.$^{-1}$. k_2, k_4, and k_6 are decreased from 0·9 to 0·09 μmolar^{-1} sec.$^{-1}$ to give the steady state concentration changes shown in units of 10^{-8} molar. Values for k_5 and k_9 are given in the table

$$\begin{tikzcd} S \arrow[r, "k_1 = 0\cdot9"] & \mathrm{RPN} \arrow[r, "k_3 = 0\cdot9"] & b \arrow[r, "k_5"] & c \arrow[r, "k_7 = 0\cdot9"] & a \arrow[r, "k_8 = 0\cdot9"] & a_3 \arrow[r, "k_9"] & O_2 \\ & A \arrow[u, "k_2"'] & A \arrow[u, "k_4"'] & A \arrow[u, "k_6"'] & & & \end{tikzcd}$$

k_5	k_9	RPN	b	c	a	a_3
0·9	0·10	− 26	− 47	− 30	+ 23	+ 44
0·9	0·07	− 12	− 5	+ 18	+ 85	+ 49
0·9	0·04	− 4	+ 14	+ 33	+ 85	+ 25
0·2	0·5	− 10	+ 17	− 12	+ 12	+ 7

this single assumption, one may make an accurate mathematical model of the complex sequence of reactions. The equations for electron transfer through the eight bimolecular steps are written in a shorthand notation in which each chemical equation consists of the reactions above one another, the velocity constant and reaction products being indicated by following the arrows[2]:

$$O_2 \xrightarrow{k_1} a_3''' \xrightarrow{k_3} a''' \xrightarrow{k_5} c''' \xrightarrow{k_7} c_1''' \xrightarrow{k_9} b''' \xrightarrow{k_{11}} fp \xrightarrow{k_{13}} \mathrm{RPN} \xrightarrow{k_{15}} \mathrm{AcAc}$$

$$O_2 \xleftarrow{k_1} a_3'' \xleftarrow{k_3} a'' \xleftarrow{k_5} c'' \xleftarrow{k_7} c_1'' \xleftarrow{k_9} b'' \xleftarrow{k_{11}} rfp \xleftarrow{k_{13}} \mathrm{RPN} \xleftarrow{k_{.5}} \mathrm{BOH}$$

Additional reactions causing inhibition of the bimolecular processes are represented by the combination of an inhibitory substance (*I*) with one of the reactants, so that the concentration of the reactant available for electron transfer is diminished. Physical argument readily indicates that an inhibitor acting at a single point by combining, for example, with the reduced form of a respiratory component would cause a decrease in the concentration of the oxidized form of those components on the substrate side of the interaction site, and an increase in the concentration of the oxidized form of those components on the oxygen side of the interaction site. Thus when there is only one interaction, the site is invariably identified by a − to + cross-over.

Table 2 gives values for the changes of the steady-state oxidation-level of the cytochrome components in response to a decrease in the velocity constant for interaction with the substance *A*. This simulates the exhaustion of added adenosine diphosphate. In this calculation we have summed the concentrations of the active and inactive forms of the intermediate, since in the chemical system these are apparently spectroscopically indistinguishable[3]. The first row of data simulates conditions for the cytochrome chain where the cross-over point is found between cytochromes *c* and *a*. A decrease in the velocity constant for the oxygen reaction (experimentally caused by the addition of azide[12]) can move, in successive steps, the cross-over point to between components *b* and *c* or between components reduced pyridine nucleotide and *b* as indicated in the second and third rows. These analogue-computer data verify the method which we have used experimentally for showing that three sites of interaction exist in the respiratory chain of mitochondria. In the fourth row the velocity constant between cytochromes *b* and *c* is diminished and a 'reversed cross-over' is obtained. The − to + cross-over points between reduced pyridine nucleotide and *b* and between *c* and *a* are, however, valid indications of interaction sites.

In a five-component system, together with further data not included here on a seven-component system, this analogue computer representation of three sites of interaction affords a basis for restatement of the cross-over theorem in a more useful form than that given previously. We will state the theorems that apply to a system involving flux from a substrate to oxygen through a series of carriers which exist in oxidized and reduced forms. The reduction of components is denoted by − and their oxidation by +. For interactions that cause decreases of flux, we can state: (1) an interaction site lies between a − to + change in the sequence from substrate to oxygen; (2) components between oxygen and the first site will always show + changes, while those between substrate and the last site will always show − changes; (3) a cross-over point near the oxygen end of the chain can be shifted to the next site of interaction by a decrease of activity in the oxidase portion of the chain and vice versa; (4) a + to − change (reversed cross-over) does not identify an interaction site.

These theorems appear to apply to many other types of systems, for which the term 'substrate' can be replaced by the term 'source' (source of flux) and 'oxygen' by 'sink' (a sink for the flux). In this case, 'reduction' (−) implies an accumulation of the source material and 'oxidation' (+) a depletion of the source material. In the case of a semi-conductor, the substrate would be represented by electrons and the oxygen by holes.

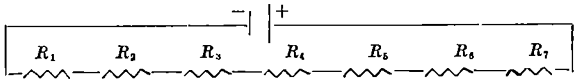
The demonstrability of cross-over points for all sites of interaction depends on a number of factors, the most important of which are the intensity of the interactions and their effect upon the flux through the system. Another factor to be considered is the steady-state level; components which are nearly fully oxidized or reduced may show changes that are difficult to measure, since a component that is highly oxidized will be insensitive to an oxidizing interaction and vice versa. In such cases, inhibitors are useful to alter steady-state levels and thus to increase the demonstrability of cross-over points. Inhibitors also shift the cross-over point from site to site along the chain and thereby allow successive demonstrations of the interaction sites of the chain.

Current- and Fluid-flow Models

Holton[10] and, more recently, Lundegårdh[13] have respectively proposed current- and fluid-flow models for the electron transfer system, and the former has made a detailed study of the response of the current-flow model to changes of resistance[10] to determine whether it simulates cross-over behaviour. His corrected results[11] agree with the generalization obtained with the analogue computer and show the movement of the cross-over point (− to + change) with decreases of flux illustrated in Table 3 together with a + to − change also indicated by the last row of Table 3. Such a reversed cross-over does not indicate a site of interaction (see below).

One of us (C.M.C.) has made a complete analysis of a current-flow model containing seven resistors in which R_2, R_4, and R_6 may be increased (see Table 3). It is found that ΔE_1 is always negative and ΔE_5 and ΔE_6 are always positive. We define, in accordance with Table 1, a cross-over point as a − to + change

Table 3. CROSS-OVER BEHAVIOUR OF A CURRENT-FLOW MODEL, ILLUSTRATING THE CONCEIVABLE RESPONSES TO DECREASES OF CURRENT FLOW CAUSED BY INCREASES OF RESISTANCE AT THREE SITES—R_2, R_4, AND R_5



	ΔE_1	ΔE_2	ΔE_3	ΔE_4	ΔE_5	ΔE_6
a	−	−	−	−	| +	+
b	−	−	−	| +	+	+
c	−	−	+	+	+	+
d	−	| +	+	+	+	+
e	−	+	+	−	+	+
f	−	+	−	−	+	+
g	−	+	−	+	+	+
h	−	−	+	−	+	+

proceeding from e_1 to e_6 in response to a decrease of flux or current flow. If one sets down all the conceivable combinations of signs for ΔE_2, ΔE_3, and ΔE_4 an analysis of the circuit shows rows *a*, *b*, *d*, *e*, *f*, and *g* to be realizable with appropriate changes of flux. Thus all three sites of interaction can be readily identified by the − to + cross-over. Rows *c* and *h* appear to identify false sites of inhibition, but the analysis further shows that no combination of resistance changes can possibly produce potential changes leading to rows *c* and *h*. In summary, a − to + change associated with a decrease of flux identifies one of the sites at which interaction has occurred.

Neither the current- nor the fluid-flow model represents the bimolecular interaction of electron transfer in the chemical system. The reaction of soluble cytochrome *c* with the cytochrome *a* component of a solubilized cytochrome is bimolecular:

$$c'' + a''' \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} c''' + a'' \qquad (1)$$

This reaction holds for lower cytochrome *c* concentrations, although the reaction at high cytochrome concentrations is complicated by the fact that this substance is inhibitory[14]. No reversibility of the reaction has been demonstrated, that is, $k_1 >> k_{-1}$. The same rate law holds to a reasonable accuracy[22] for systems in which the carriers are bound to structures which, in the case of the mitochondria, are probably the cristae. The current-flow model (Holton, F. A., personal communication) appears to represent equation 1, but k_{-1} must be equal to k_1, a condition clearly not true for the chemical system. A more general analysis shows that the current-flow system represents, in addition to the reversible system of equal forward and reverse velocity constants, an irreversible system with a rate constant equal to the reciprocal of the sum of all the resistances.

The kinetic response of the current- and fluid-flow models is not representative of equation 1. While Holton makes no claim that the current-flow model represents chemical kinetics, Lundegårdh does so for the fluid-flow model. The chemical equation for the next step in the reaction is:

$$a'' + a_3''' \overset{k_3}{\rightleftharpoons} a_3'' + a''' \qquad (2)$$

From equations 1 and 2, the differential equation for $k_{-1} = 0$ has two product terms:

$$-\frac{da'''}{dt} = k_1 c'' a''' - k_3 a'' a_3''' \qquad (3)$$

As illustrated by this example, and for any mechanism in general, the rates of reactions in a cytochrome system depend on two chemicals, since oxidation-reduction reactions are involved. The systems of Lundegårdh and Holton depend on the analogue of only one chemical, and thus differ in a most fundamental way.

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WATER RESOURCES AND WATER NEEDS IN SCOTLAND

A SYMPOSIUM on "Water Resources and Water Needs in Scotland" was held by Section E (Geography) of the British Association on September 1. The following papers were read: "The Need for River Flow Studies", by R. Maclagan Gorrie (Royal Scottish Geographical Society); "Measuring River Flow and Estimating Floods", by P. O. Wolf (University of London); "Evaporation and Land Use in Water Conservation Studies", by F. H. W. Green (Nature Conservancy); "Hydro-electric Development in Scotland", by P. L. Aitken (North of Scotland Hydro-electric Board); and "Industry in relation to Water Supply", by L. B. Aitken (Scottish Council Development and Industry).

The abundance of pure water has in the past been a major influence in the siting of Scottish developments such as the early linen and cotton mills, paper making, brewing and distilling. It also fixed the sites for aluminium production, and, more recently, for the North of Scotland Hydro-electric Board's sites in Perthshire, Argyll and Ross. The new atomic power stations and chemical factories make very big demands on water supply, so requests for 5 million gallons a day are now common.

The demand for electricity in Scotland is growing by 7 per cent per annum, so that new power stations have to be planned to meet a doubling of output every ten years. The base load which is maintained over the whole twenty-four hours can best be met by steam or nuclear stations, but the fluctuations above this minimum are a different matter, and can best be met from steam power or by hydro-electric stations. The peak load may be for only a few hours in each day but will cost three times as much as the base load to produce. Hydro-electric stations of the conventional or of the pumped-storage type are best suited to produce the peak load and can do so at less cost.

Scottish river supplies are thus so valuable that every effort must be made to safeguard them, and the use of this basic resource must be planned. The behaviour of rivers can best be judged from stream-gauge records, but the amount of water reaching a stream-bed is an uncertain fraction of the rain which has fallen within its catchment. To get an accurate picture of the value of a river we must therefore have a knowledge of the rainfall, not only in total but also in intensity, and with enough rain-gauges to provide a grid which will show the pattern of local storms.

Stream-gauging has lagged seriously behind other countries; in Scotland it was left to private initiative, the pioneer being Capt. W. N. MacClean, who, at his own expense, undertook gauging from 1912 onwards on the Rivers Garry, Moriston, Ness, Lochy and Dee. The data he recorded are of great value, but unfortunately this was not appreciated when he offered them to various Scottish bodies; these records are now being used by the London School of Economics for the training of hydrologists.

The "Surface Water Year Book", now issued officially, covers from 1945 onwards. The Scottish mainland has forty-two major catchments, out of which rainfall–run-off data are presented for sixteen of them or their tributaries. Unfortunately, in the case of two of our most important rivers, the Tay and the Spey, the rainfall data are considered by the Meteorological Office to be inadequate to present rainfall in detail, and the flow of both is affected by transfers of water between the two across their common watershed for hydro-electric supply. Excluding the Tay and Spey, ten catchments of more than a hundred square miles and seven catchments of less than a hundred square miles are recorded, so that their rainfall–run-off ratios can be determined. The readings for all of them for a number of years give a straight-line graph showing a ratio of run-off (A) to rainfall (R) of $A = 7R/8 - 8$ (in inches). This differs radically from that given for the Thames basin by E. C. Bilham, in which $A = 0{\cdot}57R - 6{\cdot}05$ (in inches). This confirms that their behaviour is radically different, as must be expected considering the greater altitude and heavier rainfall of the Scottish Highlands and the very large area of peat which covers them.

Evaporation (including the transpiration from plants) is the largest single item in accounting for the difference between rainfall and run-off. In assessing this loss, two fundamentals have to be separated, namely, the energy causing the evaporation and the water available for the process. By guarantee that water supply is never a limiting factor, we arrive at a figure of 'potential evaporation' which can be considered as a climatic factor comparable with, say, rainfall or air temperature, but to make valid comparisons there must be more or less arbitrarily defined standard conditions.

A grass sward free of obstructions and conforming to the ordinary requirements for a meteorological reporting station has been used by F. H. W. Green, of the Nature Conservancy staff, in producing valuable contrasts in four Highland readings, as shown in Fig. 1. Kinlochewe is in the maximum rainfall belt, immediately to the west of the main watershed; Prabost in Skye is to the west of this, and Lossiemouth well to the east of it. Achnagoichan in Speyside is intermediate in an intermontane basin but at an elevation of 1,000 ft. As the effect of alternative land uses upon the available water supply is the ultimate objective, steps are now being taken to determine the potential evaporation in the centre of a large homogeneous area of spruce.

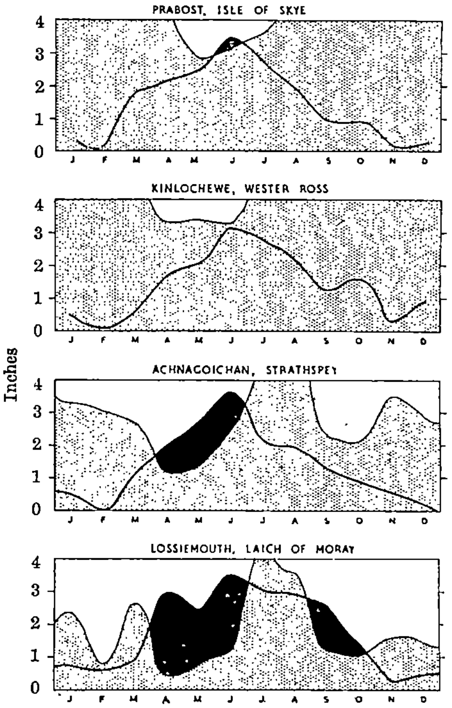

Fig. 1. -——, Rainfall; ——, potential evaporation; ■, excess of potential evaporation over rainfall, all for 1957

A historical analysis of damaging floods so far recorded in Scotland gives the impression that floods and damage occur more frequently at present than they did in the past. When one attempts to analyse this trend in terms of changing land use and run-off conditions, there is already apparent a widespread deterioration in the condition of our moorland peat as a ground cover. This has been brought about by the moor burning, which has increased in many districts as an answer to the coarsening of the grasses following upon the use of sheep only over a long period of years. When robbed of its protective cover by fire, peat behaves in the same way as any other eroding soil; in the first heavy rain after the fire it forms a surface slime which seals off the top, thus preventing normal penetration of the rain through the underlying layers of soil and rock to join the water-table. Instead, it all goes off in surface run-off which, of course, increases the 'flashiness' of flood peaks.

Other changes in land conditions which contribute to damaging flood peaks are the increased bank erosion along many of our highland streams, the use of heavy drainage ploughs on sheep-runs and afforestation areas, and the commercial 'skinning' of peat from the bogs for commercial purposes. Flood intensities are clearly a function of the intensities of rainfall and of the catchment characteristics, including the limits of retention capacity as influenced by land use and misuse. The hydrological estimate of 'maximum possible floods' or 'probable maximum floods' starts, however, with studies of storm maxima, either by transposing the worst recorded storm for the region on to the catchment in question, or by building up from other meteorological data.

Since the Reservoir (Safety Provisions) Act, 1930, has laid the responsibility for checking the safety of dams upon a panel of engineers, the technique advocated in the Institution of Civil Engineers' Interim Report, 1933, is to plot the peak discharges for all the recorded rivers in Britain in cusecs per thousand acres of catchment for the actual catchment area ; the curve thus produced has been of the greatest value as a guide in experienced hands. A revision of this report is now in preparation and will include flood data collected between 1933 and 1957, and this will be a further step in helping the designers of dams and also those wrestling with flood forecasting.

Local authorities are continually trying to attract new industry to their area, but in many cases do not know what their water resource amounts to. Demands of 5 million gallons a day, or even 20 million, are now met with ; but the number of sites which can cater for such demands is limited, and when the few still to be exploited in England are used up, there will remain only the Scottish Highlands. Unfortunately, we do not know the potential of many Scottish rivers and it is imperative that more data and more reliable data should be collected. Guesses are not good enough ; an industrialist will site his factory where he knows there is enough water, and not on another more desirable site where there might be enough.

In the past it has not been the duty of a local authority to measure river flows. It is a highly specialized job and an expensive one if carried out according to the high standards of the Land Drainage Division of the Department of Agriculture for Scotland. The programme of the Division is being greatly extended; but even so, only a fraction of Scottish rivers is now being measured. Under the river purification boards now appointed for eight lowland rivers in Scotland, minimum or nadir flows are being measured, as this is the crucial figure needed to determine permissible pollution. Other county officers, including planners, road engineers and police, want data for safety precautions and flood warning systems, and are adopting various types of gauging less expensive than the Land Drainage Division's specification.

The Royal Scottish Geographical Society has recently established a standing committee for river flow studies and is defraying the expenses of meetings ; the group includes the four university geography departments, civil engineers, land drainage and water use specialists, meteorologists and land use planners. The main tasks are to collate flood records, review any research work and encourage fresh efforts in research and survey of river behaviour, and ensure publication of suitable material ; to advise local authorities when called upon ; and where warranted, to agitate for action on flood control ; to arrange the formation of 'flying squads' for immediate reconnaissance of floods as they occur ; and to encourage longer-term studies bearing upon evapo-transpiration and the ultimate demands on existing water supplies. So far, the committee's main function has been to provide a platform for discussion ; the organization is a very long way behind its Danish counterpart, the Hydrology Section of the Danish Heath Society at Slagelse. Hitherto, efforts to get funds have failed and the programme is crippled because of this.

The measurement of the flow of water, starting with surface run-off and finishing in the sea, can properly be considered the sphere of geographers skilled in hydrometry ; the basic knowledge must needs include the ecology and geology of the catchment as well as the engineering of a gauging site, the best equipment for the given conditions, and the drill for using the instruments properly. Too much of current press writings about floods and water resources shows a superficial approach. It is hoped that this may be counteracted to some extent by getting an increasing number of geographers using a scientific approach and in close collaboration with the engineers to undertake hydrometric work as well as climatological stations, and so build up a fuller knowledge of the nation's water resource.

R. Maclagan Gorrie

NUCLEAR POWER STATIONS

WORLD PLANS AND EXPERIENCE

At the first Geneva Conference on the Peaceful Uses of Atomic Energy in 1955 only the U.S.S.R. could claim to have a nuclear power station in operation, and that on little more than an experimental scale. Producing 6,000 kW., it was generally considered, from the description provided, to be no more than a demonstration of feasibility. The building of Calder Hall was well advanced, but it was not in operation and its economy and reliability were still to be demonstrated. The United States, with ample and cheap supplies of fossil fuels, felt less urgency for the development of nuclear power stations and greater difficulty in achieving economic parity with conventional stations at home.

The three years between the first and second Conferences at Geneva have seen very great advances in this field in many countries. The feasibility of nuclear power stations is no longer in question and discussion now centres on the type of reactor to be used, the date by which it will provide electricity as cheaply as conventional stations, in particular national economies, and the rate at which nuclear power stations can be built. In 1955, only the United Kingdom had a national nuclear power programme, and it is significant of the rate of advancement in this period that within two years this programme had been substantially increased, based on the development potential revealed by the design of the first stations. At the second Conference recently concluded, a number of countries presented papers setting out their plans for the construction of nuclear power stations, not as vague and distant hopes, but covering generally the next decade and based on careful assessments of demands for electricity, supplies and costs of fossil fuel, the economics of reactor systems and the availability of finance and technological man-power.

Between those countries where fossil fuel or hydro reserves are at present adequate, such as the United States and Sweden, and those which urgently require a new source of energy, such as Japan and Italy, there are a number of differences which have led to two main approaches. The former group tend to have wide ranging programmes of prototype demonstration reactors, whereas the latter concentrate on systems already developed in other countries. Western Europe, through the agency of Euratom, may be in a special position, combining concentration by individual countries with diversity over the whole Euratom area.

Running through most of the papers presenting national programmes is the determination to achieve ultimate independence, at least in the design and construction of the stations, although several countries will clearly have to rely on imports of uranium and thorium for fuel. At the same time, there is recognition of the heavy demands on scientific and technological man-power, as well as on industrial capacity, which the development of a reactor system to a commercial scale makes, and the realization that in the early stages there must be some degree of dependence on other countries.

For those countries which have accepted the need to import their first nuclear power stations, the choice virtually rests between two systems: the graphite-moderated, gas-cooled reactor developed from Calder Hall, and the water-cooled and moderated systems, in the form of the pressurized water reactor at Shippingport and the boiling-water reactor nearing completion at Dresden in the United States.

No very clear picture as to the relative merits of cost of power in these two types of station emerged. The gas-cooled reactor has high capital cost, which may be reduced if it is built for the large outputs of which it is capable, and low fuel costs. The boiling-water reactor, particularly, appears to have low capital costs but these are associated with higher fuel charges. Thus, an economic comparison is very dependent upon the size of station to be built and the rate of interest chargeable to the capital investment. The fact that the former uses natural uranium, thereby eliminating the need for a diffusion plant or the importation of enriched fuel, offers the prospect of earlier national independence.

Although the number of power reactor systems already built and operating is limited, the range will clearly be extended in the near future, with the United States and the U.S.S.R. leading the way in diversity. The United States, having adequate conventional fuel resources, has been concerned chiefly with the development of reactors for submarine propulsion, and in the field of electricity generation has encouraged the construction of power demonstration reactors, of relatively small output, primarily with a view to export. The availability of comparatively cheap enriched uranium has been invaluable in permitting the study of small reactors of various types, but it is noteworthy that the U.S. Atomic Energy Commission has also turned its attention recently to the gas-cooled, graphite-moderated system.

The United Kingdom, while pursuing its policy of concentrating its main effort on developments of Calder Hall to provide large units for the home market and introducing modifications such as ceramic fuel and beryllium cans to permit higher operating temperatures and consequent greater efficiency, is considering alternatives such as the replacement of graphite by heavy water as the moderator. That such alternatives must satisfy the criterion of offering economic advantages over developments of the Calder Hall type is clear from the announcement of the abandonment of work on the sodium-cooled graphite-moderated system, which was adjudged to offer no economic inducement. Both the United Kingdom and the United States are devoting considerable effort to the longer-term project of a fast fission reactor, and the advantage of the positive breeding gain which this system permits has been widely recognized. Thus, the Japanese paper speaks of relying on foreign thermal reactors for the early stages of the programme, while concentrating Japan's own research and development effort on the design of breeder reactors to be available commercially about 1970.

Reviewing typical national programmes, it is interesting first to compare the countries in which the need for nuclear power is most urgent. The plan to provide 5,000–6,000 MW. of installed capacity in the United Kingdom by 1966 is well known. In Italy, five organizations are each planning to build a station, the combined electrical output being 900 MW., but no precise time-scale is set. The Japanese paper gives detailed economic analyses, both of the cost of stations and the relation of expenditure to the estimated national income. Besides setting targets of 600 MW. by 1965 and 7,000 MW. by 1975, it forecasts that the proportion of equipment manufactured in Japan would rise from 60 per cent in the period 1962–65 to 93 per cent after 1967. The Netherlands, with a present import of about half its fuel supplies and an increasing demand, proposes to have 3,000 MW. of nuclear power station capacity installed by 1975, sufficient to supply 50 per cent of the electrical output. The first step towards this aim is a 100-MW. station in operation by 1962.

France normally imports about 40 per cent of the energy it consumes, the security of which must be dependent on adequate trade balances and also on satisfactory political conditions. The discovery of uranium ores in metropolitan France led to a power programme similar to, but smaller than, the British, in which the most economic system was sought. The early stations, which employ natural uranium and are moderated by graphite and cooled by carbon dioxide, have been designed as prototypes, each differing somewhat from the next (both horizontal and vertical fuel channels have been tried and pressure vessels have been constructed both of prestressed concrete and of steel). The present programme is for two civil power stations to be completed by the middle of 1961 totalling 233 MW. This series of reactors is then to be continued by putting into operation every eighteen months an additional plant, more powerful and more efficient than the preceding one.

Western Germany, with no urgent need to supplement conventional sources of power and a tradition of scientific and industrial ability, plans to investigate a range of reactor systems, including some of its own design, and expects by 1965 to have in operation four or five 'demonstration' stations each producing about 100 MW. of electricity. These stations will be built for utility companies and not for the Government, though it is proposed that one-third of the capital shall come from public funds. With several research reactors from the United States and the United Kingdom, and bilateral agreements with Canada and the United States for the supply of uranium concentrates and enriched uranium respectively, Western Germany is making great efforts to overcome the handicap of a late start in the field of atomic energy.

At the other end of the scale, both the U.S.S.R. and Poland state that their fossil fuel deposits are adequate and they have no present need for nuclear power, though the Soviet Union makes the exception that it would be useful in certain remote areas. Although they had not reported any new stations since the one they described in 1955, the Russians announced during the Conference the construction of a station in Siberia with an ultimate output of 600 MW.(e). The information given suggests that it is a dual-purpose station with electricity as a by-product. They also showed in the scientific exhibition at the Conference a design for a 150-MW. station using gas-cooled, heavy water-moderated reactors. The Polish programme is based on the conclusion that nuclear stations will be more economic than conventional stations within twenty years, and it is therefore planned to install 800 MW. capacity between 1965 and 1970, with a further 1,000 MW. capacity added in the following five years. It is hoped that the reactors in these later stations may be of the fast breeder type.

An interesting variation is provided by Sweden, where the hydro-electric capacity is adequate to meet demands for the next fifteen years, but where there is virtually no domestic conventional fuel. This lack of coal and oil, combined with the long winter, has caused the Swedish programme to be directed towards the use of nuclear energy for district heating, with the production of electricity by back-pressure turbines as a by-product. By 1965 it is intended to build six reactors to supply heat and only one 100-MW. electrical power station. As the available hydro resources are fully utilized, an expansion in the nuclear power station programme is envisaged, providing a total installed capacity of about 2,000 MW. by 1975.

Other countries, including India, Spain and Roumania, presented papers forecasting the construction of nuclear power stations within the next few years.

The range of experience in operating power-producing reactors is at present both limited and unrepresentative, being based largely on units planned primarily for military purposes or on small-scale demonstration reactors. The 80 per cent availability reported for the Calder Hall reactors is gratifying proof of reliability, but the extremely low incidence of defective fuel elements achieved is not conclusive evidence of performance of the power station because of the relatively low level of irradiation imposed by the military requirements. In the same way, the remarkable performance of the submarine reactors cannot be taken as a reliable guide to the behaviour of a similar type of reactor designed to standards which permit the economic generation of electricity. Thus, both the running costs of the present type of power reactors and their span of useful life, which have an important bearing on the assessment of their economics, can only be finally established when a significant proportion of their estimated life of fifteen or twenty years has been achieved.

Nevertheless, there was at the Conference a high degree of confidence in all the countries concerned that these factors would prove to be favourable to the economic generation of power.

UTILIZATION OF INORGANIC NITROGEN SOURCES BY PLANTS

ONE session of Section K (Botany) of the British Association meeting at Glasgow, held on August 29, was devoted to a consideration of the problems involved in the utilization of inorganic nitrogen sources for amino-acid and protein synthesis by plants. Emphasis was primarily upon the nitrogen fixation process, although recent progress in the use of combined inorganic nitrogen sources was also reviewed.

Dr. G. Bond (Glasgow) stressed that nitrogen fixation constitutes one of the few fundamental processes of the living world and serves to maintain the supply of combined nitrogen in soils and oceans. Without fixation the opposing actions of the denitrifying bacteria would probably reduce the nitrogen status of natural soils to levels incapable of supporting most forms of plant life.

What, then, are the organisms capable of effecting nitrogen fixation ? During a critical review of recent evidence gained largely by the use of the heavy isotope of nitrogen (nitrogen-15), Dr. Bond concluded that no faculty for fixation resides in members of the Angiosperms, Gymnosperms, Pteridophytes or Bryophytes except where there is symbiosis with certain lower organisms. Some blue-green algae (*Nostoc*, *Anabaena* and *Cylindrospermum*) have long been recognized as efficient nitrogen fixers. Certain other members of the Cyanophyceae are incapable of fixing nitrogen, as are all green algae so far tested. The position of the fungi is less certain, and much confirmatory work would seem desirable. While the nitrogen nutrition of most fungi would undoubtedly seem to be based on combined nitrogen, there is preliminary evidence that certain fungi (soil yeasts assigned to the genera *Saccharomyces* and *Rhodotorula*) have some capacity for fixing nitrogen.

The main free-living nitrogen-fixing organisms are without doubt to be found among the bacteria. The genera *Azotobacter* and *Clostridium* include species with an almost world-wide distribution that can effect nitrogen fixation. However, it remains uncertain whether they are sufficiently abundant in soils to permit of extensive nitrogen fixation. Other species for which there is evidence of ability to fix nitrogen include *Azotomonas*, *Aerobacter*, *Desulphovibrio*, *Methanobacterium* and *Pseudomonas* ; positive results have also been obtained for photosynthetic bacteria, including *Rhodospirillum*, *Chromatium* and *Chlorobium*, and so these species match the Cyanophyceae in metabolic powers.

In many plant habitats symbiotic nitrogen fixation is probably much more important than any of the above types of asymbiosis. Nitrogen fixation by legumes, the root nodules of which contain *Rhizobium* as the endophyte, has been a basic agricultural practice and is still of great importance in certain less industrialized countries. In areas of natural vegetation other Angiosperms capable of forming root nodules may be more important than the legumes. Eight genera so far seem important: these are *Hippophae, Elaeagnus, Shepherdia, Myrica, Casuarina, Coriaria, Alnus* and *Ceanthus*. Undoubtedly the fixation is due to the presence of symbiotic micro-organisms within the nodules, but the nature of these remains uncertain. The importance of certain of these species in the maintenance of nitrogen fertility may well have been greater in earlier times. Alder and bog-myrtle were very prevalent in Britain in pre-agricultural times and they may then have been the principal nitrogen fixers. Recent direct evidence indicates that in Alaska alder figures regularly in plant succession on recently de-glaciated lands and has served to increase soil nitrogen markedly. Sea-buckthorn (*Hippophae*) was another plant that rapidly established itself after the ice-age in Scandinavia and possibly in Britain; this may have been due in part to its possession of nitrogen-fixing nodules.

A number of Gymnosperms, particularly members of the family Podocarpaceae, bear large numbers of nodular structures on their roots. Although reports exist that nodulated plants of *Podocarpus* can continue to grow actively without a combined nitrogen supply, studies with nitrogen-15 have failed to confirm the ability of the plant to fix nitrogen. Various members of the Cycadaceae also produce nodulated roots resembling those of alder. These nodules appear to contain an alga identified as a *Nostoc* or *Anabaena* species, and when detached nodules of *Ceratozamia* and *Encephalartos* were exposed to elementary nitrogen-15, clear evidence of strong nitrogen fixation was obtained. The earlier dominance shown by the cycads in many parts of the world may have been associated with their ability to utilize elementary nitrogen at a time when the combined nitrogen status of most soils was comparatively low.

Several other intriguing possibilities for symbiotic nitrogen fixation exist. The nitrogen-fixing bacterium, *Beijerinckia*, has been isolated from the leaf surfaces of several Indonesian plants and may make symbiotic nitrogen fixation possible. The 'leaf-nodules' (cavities in the leaf surfaces containing dense growth of bacteria) of *Pavetta, Psychotria* and *Chromelia* have been assigned nitrogen-fixing ability. Cavities containing nitrogen-fixing blue-green algae are also known; thus, the water-fern *Azolla* is associated with *Anabaena*, while certain liverworts, including *Blasia*, accommodate *Nostoc*. Finally, the lichens seem to provide other examples of symbiotic nitrogen fixation. About 8 per cent of all lichen species contain an algal symbiont of the blue-green type, and recent experiments using nitrogen-15 have provided definite evidence of nitrogen fixation in three such species (*Peltigera, Collema* and *Leptogium*). No ability to fix nitrogen resided in lichens containing a green-algal symbiont.

The other papers of the session were concerned with the physiology and biochemistry of nitrogen utilization. Irrespective of whether inorganic nitrogen-15 is supplied as elementary nitrogen, nitrate or ammonia nitrogen, the sequence in which the nitrogen-15 atoms enter organic nitrogen compounds is closely similar for most plants. This suggests that all forms of inorganic nitrogen are converted to a common intermediate before being incorporated into organic compounds. The bulk of the present evidence indicates that this intermediate nitrogen compound is ammonia. Earlier claims that hydroxylamine occupied this key position in the nitrogen fixation process seem to have been discounted.

Dr. G. Leaf (Glasgow) reviewed the older evidence showing that during the fixation of elementary nitrogen-15 by *Azotobacter, Clostridium* and soya-bean nodules, the nitrogen-15 probably first entered ammonia and then glutamic acid and the amides, asparagine and glutamine. Similar studies have been carried out in the Glasgow laboratories using nodules from the roots of alder. The pattern of distribution of nitrogen-15 atoms between various nitrogenous compounds differed significantly from that obtained with the legumes. It is noteworthy that citrulline, an amino-acid otherwise rarely encountered, is a major component of these root nodules, and was labelled with nitrogen-15 nearly as heavily as glutamate. Indeed, the labelling of the carbamyl-nitrogen atom (citrulline contains three nitrogen atoms) was substantially heavier than that of the α-amino-nitrogen of the glutamate. This quantitative difference does not, of course, mean that the primary reactions of nitrogen fixation are different in alder, since an established biochemical pathway shows that the carbamyl-nitrogen of citrulline is derived from ammonia via carbamyl phosphate. It is these early reactions and intermediates of the nitrogen fixation process that are still shrouded with mystery. A great deal of speculation exists concerning their nature and many experimental studies have been made to test the validity of the theories propounded, but as yet no unequivocable conclusions have been reached.

A synthesis of various schemes previously published was presented by Dr. Leaf (Fig. 1).

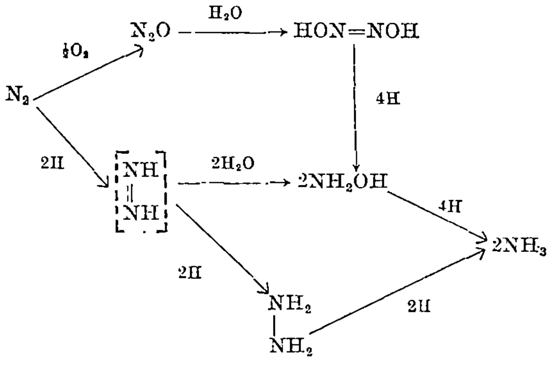

Fig. 1

Uncertainty is encountered in the very first step, which can be represented as involving either an oxidation or reduction. Crucial evidence in favour of either mechanism is still awaited. The problem of the intermediates has been approached by testing whether nitrogen-fixing organisms can utilize them, often after they have been labelled with nitrogen-15. The first intermediate of the reduction pathway postulated is not known to exist in a free form and so cannot be detected. Some support is gained for nitrous oxide as an intermediate since it acts as a competitive inhibitor of nitrogen fixation; but since it can only be utilized by *Azotobacter* at a fraction of the rate of elementary nitrogen, more conclusive evidence would seem desirable. Difficulties arise when later intermediates are tested, for they are often both unstable and toxic to the organism. However, evidence is accumulating to support the intermediary role of hydroxylamine. Hydrazine can also be utilized by *Azotobacter* but, in striking contrast to the assimilatory pathway recognized for elementary nitrogen fixation, the hydrazine-nitrogen was apparently not assimilated into glutamic acid. It is then conceivable that hydrazine is assimilated by processes having no direct connexion with those involved in nitrogen fixation. Thus, it seems probable that the precise details of the chemical pathway of nitrogen fixation will remain unsolved until appropriate conditions are found that enable active fixation to occur in cell-free extracts.

Dr. L. Fowden (London) discussed the assimilatory processes involved in the use of combined inorganic nitrogen sources by plants. The reduction pathway by which nitrate-nitrogen is converted to ammonia seems at last to have crystallized in the following form:

$$HNO_3 \rightarrow HNO_2 \rightarrow HON{=}NOH \rightarrow H_2NOH \rightarrow NH_3$$

Definite evidence is now available from Dr. Nicholas's laboratories demonstrating the existence in fungi (*Neurospora* and *Aspergillus*) of separate enzymes responsible for the catalysis of each reductive step. Naturally, one wishes to see these or similar enzymes established for higher plants. The enzymes, in showing a dependence for various metals, flavin-adeninedinucleotide and reduced phosphopyridine-nucleotides, provide a nice illustration of the importance of trace elements and vitamins in an integrated reaction sequence characteristic of plants.

In higher plants the final reduction product, ammonia, enters organic compounds by being channelled primarily into glutamic acid by reductive amination of α-ketoglutarate or into the amides glutamine and asparagine. Although suggestions are periodically made that alanine and aspartic acid may arise by similar reductive aminations of pyruvate and oxaloacetate, respectively, satisfactory confirmation of these reactions is still required for higher plant systems. Certain mutants of micro-organisms lack glutamic dehydrogenase, and here reductive amination of pyruvate seems to have been established as a major alternative pathway for ammonia assimilation.

Reactions involved in the formation of citrulline and arginine provide secondary pathways for the direct utilization of ammonia. The majority of the other amino-acids required for protein synthesis must gain their nitrogen in a less direct manner. Transamination normally provides the present-day panacea for the problems of their biosynthesis. For this to be effective, it is necessary that all the corresponding keto-acids exist in plants. However, at present only a fraction of the twenty or so acids required have been detected; it remains possible that the others exist at concentrations that are below the present limits of detection but sufficiently high to enable transamination reactions to provide amino-acids at a rate commensurate with protein synthesis.

In some ways the study of protein synthesis in higher plants is more difficult than in micro-organisms and animal tissues. Plant cells tend to store greater quantities of free amino-acids than the other types of tissue and at present it is impossible to gain a reliable insight into the distribution of particular amino-acids within the different phases of a cell. It would seem probable that in mature cells large proportions of certain amino-acids are deposited in the vacuoles and play no immediate part in protein synthesis. This conclusion receives support in that the relative concentrations of various acids in the free amino-acid pool as measured by extraction bear no similarity to the amounts in which they are required in proteins. Preliminary evidence does, however, suggest that amino-acid activating enzymes similar to those present in animal and microbial systems exist in higher plants and may catalyse the first step in the synthesis of proteins by the proposed and now familiar ribonucleic acid - template pathway.

A brief discussion followed the three formal papers. The participation of more complex organic intermediates in the nitrogen fixation process was considered and dismissed as unlikely. Various alternative concepts of the template mechanism for protein synthesis were also aired. L. Fowden

UNIVERSITY DEVELOPMENT IN BRITAIN

By Sir ERIC ASHBY

President and Vice-Chancellor, The Queen's University of Belfast

Under the title "University Development, 1952–1957"[1], the University Grants Committee has published a masterly survey of the British universities over the past quinquennium. It is a book of ninety-two pages. Its importance lies not only in the facts which it records but also in its wise and challenging comments.

On the second page is the most significant fact of all: a list of the members of the Committee. Thirteen out of the twenty names are of men and women who are, or have been, university professors or heads of colleges in universities. The controllers of university finance are at one with the controlled; and upon this simple fact undoubtedly rests the great confidence which universities and the Treasury have in one another. Membership of the Committee must be a strenuous responsibility: over the past quinquennium the Committee met fifty-one times and its sub-committees forty times, and its members spent 107 days visiting 103 institutions. It is a notable record of public service.

The factual part of the book summarizes the growth of universities since 1938–39: an increase in student numbers from about 50,000 in 1938 to about 90,000 in 1956; and in academic staff from about 4,000 to more than 10,000. The average salary paid to academics has about doubled over that period (it was £612 in 1938 and £1,323 in 1956) and the recurrent grant has risen from about £2 million in 1938 to more than £28 million in 1956. In 1938 Parliamentary grants constituted about 35 per cent of the recurrent income of the universities; in 1956 the percentage was more than 70. That such a revolution is being accomplished with so little damage to the integrity of British universities is testimony both to their stability and to the wisdom of successive governments in financing them.

The report records the changes in balance of students entering different faculties over the quinquennium. Arts (which includes law and economics) still has substantially the highest proportion of new entrants (47 per cent in 1953 and 45·6 per cent in 1956). The combined percentage of students entering faculties of science and technology rose from 34·7 in 1953 to 38·7 in 1956. The percentage entering medicine and dentistry fell from 14·6 to 12·6. These figures are reassuring, for they indicate that there is no immediate need to fear that the impact of technology on universities is going to be so violent as to imperil the vitality of more traditional studies. Indeed, there are passages in the report which suggest that the chief danger facing arts faculties may come from within themselves. They may be endangered not by a lack of recruits from the schools nor by competition from other faculties, but (of course, only in some departments in some universities) by an aridity of approach and a poverty of imagination ; a lack of fire in the belly.

It is, perhaps, a philistine approach, but nevertheless one not without its merits, to assess the efficiency of a university system by the percentage of students who emerge from universities with degrees. Compared with American or Australian universities, the record in Britain is good. The report gives some interesting data on this matter, ending with the conclusion that, from a sample of 15,256 students whose records were followed by the Committee, 16·7 per cent left without degrees. This percentage is divided into 11·3 per cent who left through academic failure and 5·4 per cent who left for reasons other than academic failure : a 'wastage' of the same order of magnitude as that reported from the Soviet Union.

One of the features of which Britain can be proud is the way in which State scholarships and local authority awards have brought the universities within reach of almost every young man or woman who is talented and who completes a grammar school education. Three out of every four students at British universities are receiving financial assistance. The proportion varies in different parts of the country : it is highest in Wales, low in Scotland (but this is partly offset by the greater numbers of students per thousand of population in Scotland) and lowest in Northern Ireland (where the sole reason is the parsimony of local authorities). But, as the report points out, the very liberality of local authorities in England causes its problems. Local authorities (quite rightly) allow students to hold awards in any university. This has two consequences : it 'creams off' the best students into a comparatively small number of universities, and so perpetuates inequalities in the intellectual standards of students among universities ; and it increases the pressure on student accommodation, for many students take advantage of this invitation to mobility by attending universities in other parts of the country in preference to universities near their own homes. The Committee sees no remedy to the first of these consequences and it welcomes the second consequence ; though it adds the rider that if more and more students are to leave home to attend universities, the universities for their part must take more trouble than some of them are taking to provide sympathetic supervision, especially during the first year.

The chapter on scientific research in universities has some interesting figures on the amount of research in universities which is sponsored by outside bodies. In the United States a dangerously high percentage of the income of a university may come from this source (one typical private university in the Middle West gets 22 per cent of its recurrent income from outside for sponsored research). The Committee's figures are reassuring : they indicate that only 6·5 per cent of the income of British universities is from this source, and half of that is from the research councils and Government departments, which in general put no restriction on the nature of the research or on its publication. Recently, the Department of Scientific and Industrial Research has taken a much more prominent part than heretofore in giving money both for research projects and for postgraduate awards ; and the Committee very carefully defines its function *vis-à-vis* the Department and the Medical and Agricultural Research Councils over the support of research in universities. The Committee ends by throwing out a challenge which some university departments may be reluctant to accept : a challenge urging universities to regard more favourably than they do at present the possibility of allowing students to work for higher degrees in research establishments off the campus and not administratively under university control.

The chapter on educational problems is convincing evidence (if any were needed) that the Committee is not only a machine for dispensing Parliamentary grants ; it is also a permanent seminar for reflexion on the problems of higher education. Earnest reformers, who would like to see commissions inquiring into university problems in Britain, would do well to ponder this chapter ; for it may well lead them to the conclusion that the sort of inquiries which ought to be made are, in fact, already being made, by a body of people who command the respect of the academic world and the confidence of the Treasury. What does the Committee regard as educational problems ? The pressure (often from professors who have not the intellectual courage to know what to omit from their teaching) to extend courses beyond the common 3-4 years ; the overcrowding of the syllabus (often on the ridiculous assumption that after leaving the university the graduate will never again learn anything new) ; the need to ensure that a graduate has a 'cutting edge' to his mind ; the very controversial question of special entrance requirements and the influence they have on general education ; the problem of teaching arts subjects in an imaginative way with due regard to exactitude and critical alertness ; the unpalatable fact that even a mediocre scientist or technologist acquires a vocational skill, whereas an arts graduate who is not going to use his subject vocationally needs to be more than mediocre—to make his education worth while the arts graduate must acquire from it not just facts (which may suffice for the mediocre scientist or technologist) but genuine mental power.

So one could go on. No virtue, no weakness, no pocket of complacency in British universities escapes the eye of the Committee. To the problems which confront universities in the coming quinquennium the Committee brings wise advice, sympathetic and tactful criticism, and lucid reasoning.

[1] University Development, 1952–1957. (Cmnd. 534.) (H.M.S.O., 1958.)

[See also p. 1210 of this issue]

OBITUARIES

Dr. N. Miller

NICHOLAS MILLER was born in Liverpool on July 4, 1916, and died suddenly at his home in Edinburgh on May 4. Into this short span was crowded a range of experiences and the growth of a reputation that any man might envy. Such was the universality of his talents that, although a classicist at school, he entered the Imperial College of Science and Technology as an entrance scholar in chemistry and had a brilliant undergraduate career culminating in a first-class degree in 1937. After two years research in physical inorganic chemistry he obtained his Ph.D. and a Commonwealth Fund Fellowship. Characteristically, Miller decided on a change not only of scene but also of academic experience, and for two years worked in oil geology and technology in the University of California. In 1941 he joined the Suffield staff of the Canadian Department of National Defence, where his numerous qualities were speedily recognized, and a few years later he was appointed to the National Research Council staff at Montreal participating in the Anglo-Canadian Atomic Energy Project.

In July 1946 Miller was transferred to Chalk River and began those distinguished investigations on the radiation-induced oxidation of ferrous sulphate with which his name will always be especially associated. In 1947 he went as an I.C.I. Fellow to the Department of Natural Philosophy at Edinburgh and in 1949 was made senior lecturer in radiochemistry. During the past ten years he has led a small, but exceptionally effective, group of radiation chemists, and from his pen there came a succession of definitive papers dealing mainly with chemical dosimetry, or more latterly, with the dependence of radical and molecular yields on linear energy transfer. The hallmark of all Miller's work was ingenious, skilfully executed and imaginatively interpreted experimentation described in pellucid prose. His advice was consequently in much demand by national and international bodies, and Miller never shirked the extra work which these duties involved.

Those who knew Miller personally will remember his modesty and integrity, his immense capacity for friendship and his remarkably infectious and tolerant grin which accompanied many a shrewd scientific comment. It is small wonder that some of his English friends have decided to perpetuate his name in annual conferences on radiation chemistry, and that the predominantly North American membership of the sixth annual meeting on Radiation Chemistry of the Gordon Research Conferences should have adopted the following memorial resolution on August 4, 1958:

"Our meeting this year is sadly marked by the untimely death of Dr. Nicholas Miller, late senior lecturer in natural philosophy at the University of Edinburgh.

"Dr. Miller was known affectionately and admired personally and scientifically by the many friends he made in the United States in the course of his repeated travel in this country in the last several years. He participated significantly in current research in radiation chemistry. Through the keenness of his criticism, the precision of his work and the breadth of his experimental and theoretical approach, he made great and lasting contributions to the maturation of the field. The warmth and generosity of his personality and the breadth of his interests outside his work proved a continual inspiration and joy to his colleagues and friends. His death is a loss to radiation chemistry, to science, and to those who had the good fortune to be influenced by him and his work."

F. S. DAINTON

Prof. K. V. Giri

KRAMADHATI VENKATA GIRI was born in 1907 and died suddenly on July 17 at Madras. Since 1950 he had been head of the Department of Biochemistry at the Indian Institute of Science, Bangalore.

Prof. Giri's output of original research extended over a period of more than twenty-five years and covered a wide range of biochemical topics. Phosphatases, especially of leaves, together with free and bound seed enzymes, were early subjects of study. In 1936, interesting observations were made on the amylase system of rice grain during ripening and germination.

Giri made contributions to the analytical chemistry of ascorbic acid and studied its stability under varying environmental conditions. In the early post-war years, vitamin B_1 in ground nut (*Arachis hypogea*) was found to be partly free and partly combined, and a series of studies appeared on the nutritive and vitamin value of this important crop. Giri published a long series of papers dealing with blood and nutrition, in which the results of research carried out in other countries were interpreted and applied to Indian conditions. Many of these papers added important new facts. In the field of the biochemistry of blood and tissues, Giri and his colleagues carried out much work on prothrombin and on nicotinic acid. More recently, radial or 'circular' paper chromatography was applied with considerable success to a variety of separations involving amino-acids, peptides, organic acids and vitamin preparations. For example, free *allo*hydroxy-L-proline was obtained from the leaves of sandal (*Santalum album*); the compound had not previously been obtained from a natural product. Agar electrophoresis was successfully applied to the study of serum of proteins. It was found that in smallpox there was an increase in all the globulin fractions and a decrease in the albumin moiety.

Prof. Giri felt the need to spread biochemical knowledge more widely and made a hobby of devising scientific films. He wanted every medical practitioner in India to have access to clinical biochemical services, and this objective was stressed through his films, writings, radio talks and lectures.

Giri was much liked and his untimely death is a loss to Indian science. He leaves a wife and four children.

R. A. MORTON
H. R. CAMA

Dr. Marie C. Stopes

MARIE CARMICHAEL STOPES, who died on October 2 aged seventy-eight, graduated at University College, London, at the time when Prof. F. W. Oliver, Quain professor of botany, was making notable contributions in the field of palæobotany. As a subject for research, she selected the ovule of the living cycads, and this took her to Prof. Goebel's institute in

Munich. The contemporary work on the Palæozoic ovules by Oliver and his associates had made the elucidation of the structure of cycadean ovules, to which the fossils were superficially compared, a real necessity. Dr. Stopes found evidence in the cycad ovules that the integument is a double structure, and simultaneously with the tentative view expressed by Oliver and Scott, concluded that it is the morphological equivalent of the inner integument and free cupular structure of the *Lagenostoma* ovule: an interpretation fundamental to our understanding of the evolution of integumentary structures.

In 1904 Dr. Stopes was appointed to the staff of the University of Manchester. Among many contributions published during the ten years she spent at Manchester was a treatise jointly with Prof. D. M. S. Watson on the distribution and origin of coal balls. Similar concretions from the Lower Cretaceous of Japan, in which country she spent some time during 1907–9, revealed an extensive flora, and several papers describing this were published, some in collaboration with Japanese botanists.

Her interest in the Cretaceous floras was to become more apparent, for at about this time she was asked to work on the collection of Cretaceous plants housed in the British Museum. The two volumes published as the "Catalogue of the Cretaceous Flora" (1913, 1915) will surely be her best-known scientific work. Preparation for this work took her to many countries. In 1911 she travelled in Canada and the United States, and in between her Cretaceous studies, discovered what were probably the very first coal balls to be found in America, and made collections from the Carboniferous 'fern ledges' of New Brunswick.

Meanwhile, Dr. Stopes had written a small textbook on palæobotany entitled "Ancient Plants" (Blackie, 1910). It was written particularly for elementary students, and was the first English textbook to bring this rapidly advancing subject before students at a non-specialist level.

She returned to University College in 1914 as a Fellow and lecturer in palæobotany. Several papers on Cretaceous plants followed the publication of the British Museum Catalogue, but throughout the succeeding years her interest became more and more centred on coal, quite apart from the plants that went into its making. Spurred, no doubt, by the effects of war, her palæobotanical knowledge was employed in the service of fuel technology. This proved a very fruitful union, and several memoirs, mostly in collaboration with Prof. R. V. Wheeler, are of fundamental importance in this field of work. Their joint "Monograph on the Constitution of Coal" (Department of Scientific and Industrial Research, 1918) set the stage for all subsequent research on this subject. The new terms (clarain, durain, vitrain, etc.) which she introduced later to the petrology of banded bituminous coal found ready acceptance, and her "Classification of Coal Ingredients" (1935) has been almost universally adopted.

Dr. Stopes founded a small museum on Portland Island, and it was one of her ambitions to make it the possessor of the largest collection of Cycadeoidea in England.

D. W. BRETT

NEWS and VIEWS

Australian University Grants Committee: Sir Leslie Martin, C.B.E., F.R.S.

In 1956, a committee, appointed by the Prime Minister of Australia, Mr. Menzies, to inquire into such matters as "the role of the university in the Australian community; the extension and coordination of university facilities; technical education at university level; and the financial needs of universities and appropriate means of providing for these needs", was set up. The committee was under the chairmanship of Sir Keith Murray, and its report was published in 1957 (see *Nature*, 181, 300; 1958). The report stated that university development in Australia could no longer be left to individual institutions or confined within the boundaries of one State, and the establishment of a permanent Australian University Grants Committee was strongly urged. This has been accepted by the Australian Federal Government, and Sir Leslie Martin has been appointed the first chairman. Sir Leslie is professor of physics in the University of Melbourne, and, since 1948, has been defence scientific adviser and chairman of the Defence Research and Development Policy Committee. He is an Australian by birth, and was educated at Melbourne High School, the University of Melbourne and Trinity College, Cambridge.

Industrial Biochemistry at Manchester: Prof. T. K. Walker

The retirement of Prof. Thomas Kennedy Walker from the chair of biochemistry in the Faculty of Technology at the Manchester College of Science and Technology brings to a close a long and active career in the service of the College. Although Prof. Walker's earliest publications concerned more particularly the field of organic chemistry, his attention soon turned towards chemical changes effected by various bacteria and moulds with particular reference to those of interest to the brewing and fermentation industries. This is reflected in the prominent position occupied by such topics in a series of almost two hundred publications which appeared in conjunction with various collaborators over a period from the late 1920's to the present day. The importance of his work in this field received recognition in 1956 with his elevation from the position of reader in fermentation processes to professorial status. More recently, the work of his school has received further stimulus from the fact that with the growing recognition of the need for further technological education the Manchester College is being expanded to provide, among other improved facilities, an enlarged school of biochemistry with excellent facilities both for research and teaching. Quite apart from his valuable material services to science, Prof. Walker will take with him into retirement the exceptionally high personal regard of a large number of former students and colleagues.

Prof. A. A. Eddy

The Councils of the University of Manchester and the Manchester College of Science and Technology have approved the appointment of Dr. Alan A. Eddy to the chair of biochemistry in the Faculty of Technology from January 1, 1959, in succession to Prof. T. K. Walker. Dr. Eddy, who will be thirty-two on taking up his appointment, was educated at Devonport High School and entered the University of Oxford with an open scholarship in natural science in 1945. He graduated in chemistry with first-class honours and later undertook research under Sir Cyril Hinshelwood into the metabolism of alkali metal ions by bacteria, which formed the subject of his thesis for the D.Phil. degree. Having been awarded an Imperial Chemical Industries Research Fellowship, he afterwards participated in the well-known work of Sir Cyril's school on the adaptive behaviour of micro-organisms. In 1954 Dr. Eddy joined the staff of the Brewing Industry Research Foundation, later assuming responsibility for the department of microbiology in which, under the successive directorship of Sir Ian Heilbron and Dr. A. H. Cook, he was able to develop his interest in the chemical aspects of yeast structure. In this connexion his work on the wall of the yeast cell may be specially mentioned as throwing new light on various important aspects of the behaviour of yeast during industrial fermentations, while his development of methods for isolating nuclear bodies from yeast represents an outstanding achievement in a more academic field. Dr. Eddy is the author or joint author of a large number of original memoirs and, in keeping with his future responsibilities, he has been closely associated with various projects for developing the application of continuous methods of fermentation, a subject of growing importance in the industrial field.

Frederick Soddy Memorial Plaque

On October 25, Eastbourne was visited by members of the Soddy Memorial Trust, whose chairman, Sir Gerald Campbell, invited the mayor, Councillor J. W. G. Howlett, to unveil a memorial plaque on the house in Bolton Road where Frederick Soddy was born and passed his early austere and motherless days. At a previous commemoration luncheon, Councillor Howlett expressed the pride of the town in its famous son, who had predicted the wide-scale use of energy from the atomic nucleus. Following a well-attended film show arranged by the Institute of Atomic Information, the Trustees visited Eastbourne College, where Dr. F. M. Brewer was invited to unveil a memorial plaque in the new Soddy Senior Chemistry Laboratory, a notable extension of the laboratories where Soddy began his chemical studies ; it has recently been provided by the Industrial Fund for the Advancement of Scientific Education in Schools.

The Second Soddy Memorial Lecture was given by Dr. F. M. Brewer, of the Inorganic Chemistry Laboratory, Oxford, where he became a pupil of Soddy in the early 1920's. He recalled many personal facets of the formulator of the theory of disintegration and of the displacement law, which culminated in the establishment of isotopy and radiochemistry. Soddy always exhibited a great natural charm and generosity of thought, he said, especially towards his students and those with whom he collaborated, which persisted throughout his life and was augmented by the outstanding sociability of his wife. Soddy made little immediate impression on the authorities at Oxford, however, and his extensive work during the First World War at Aberdeen was cut short. Thereafter he became a passionate advocate of the widest use of science for furthering social progress. The local and national neglect of applied science prompted him to investigate political and monetary systems, which provoked academic criticism. Soddy was widely cultured, a mountaineer, an explorer of knowledge in other fields, and a man of the highest integrity, particularly when attributing priority to scientific discoveries and their interpretation. He remains a great man and a fundamental pioneer towards the utilization of nuclear energy. His impact on science is fully documented in "The Life Story of Frederick Soddy", by Muriel Howorth, the first copy of which was presented to the Eastbourne College Library by the author.

Windscale Pile No. 2

The Atomic Energy Authority has decided not to restart Windscale Pile No. 2. The cost of the measures which Sir Alexander Fleck's Technical Evaluation Committee recommended should be taken before restarting Pile No. 2 would be in the region of £500,000. If this cost were incurred and the pile restarted, the plutonium produced over the estimated remaining life of the pile would be extremely expensive. Plutonium is now being produced in substantial quantities from the Calder Hall reactors, and the Chapelcross reactors will come into operation during the next year. The fuel will now be discharged and reprocessed for other uses ; equipment will as far as possible be removed, and certain of the buildings will be useful for experimental purposes, saving expenditure which would otherwise have been necessary. This decision will not give rise to any redundancy. The programme of work of the chemical processing plant at Windscale is increasing, and the workers employed on the two piles will be re-allocated to other work.

Use of Radioactive Substances and X-rays in Schools

The Minister of Education, in Administrative Memorandum No. 577 (October 1958) to local education authorities and secondary schools, has announced that, although such work is normally more appropriate to university courses, a small number of schools are introducing demonstrations and experiments involving radioactive substances and sources of X-rays. In view of the possible risks to health of those engaged in such work, and after consultation with the Radioactive Substances Advisory Committee and the Atomic Energy Authority, it has been decided that special authorization will have to be obtained by any school wishing to conduct such work. The Minister will grant authorization, which will be reviewed annually, only where he is satisfied that the necessary safety precautions are maintained. The Minister also requires that he be notified by all schools employing X-ray and other apparatus operating at voltages greater than 5 kV., so that the appropriate protective barriers may be specified, without which such apparatus may not be used. Notes for the guidance of schools in the use of radioactive materials and of equipment producing X-rays have also been issued.

Wellcome Trust: Grants for Research

The Wellcome Trustees have announced that among the grants made during the half-year ended August 31 were the following : up to £60,000 to the Post-graduate Medical School of London for the cost of including a Wellcome Research Library in the proposed new buildings ; up to £37,000 to the Institute of Psychiatry, Maudsley Hospital, to provide laboratories in which integrated research by the Departments of Neuro-endocrinology and Neuropathology may be carried out ; up to £36,500 to the Department of Anatomy, University of Birmingham, to extend the research laboratories and animal accommodation ; up to £25,000 to the Department of Zoology, University of Edinburgh, to provide additional research accommodation ; £50,000 to the University of Western Australia to endow a Wellcome Research Department of Pharmacology ; up to £17,000 to the Institute of Medical Research, North Shore Hospital of Sydney, Australia, to build and equip laboratories for experimental medicine and surgery. In addition, three electron microscopes are being purchased at a cost of approximately £34,000 for indefinite loan to the following institutions: the Biophysics Research Unit of the Medical Research Council, King's College, London (Prof. J. T. Randall) ; Sir William Dunn School of Pathology, University of Oxford (Sir Howard Florey) ; London School of Hygiene and Tropical Medicine.

Australian Society of Plant Physiology

AT the University of Adelaide on August 19, plant physiologists from all the States of Australia attended a meeting convened by Dr. R. N. Robertson, head of the Plant Physiology Unit of the Commonwealth Scientific and Industrial Research Organization in Sydney, to consider the formation of an Australian Society of Plant Physiologists. The sixty scientists present decided unanimously to constitute such a society, with the aim of advancing the science of plant physiology. A constitution was adopted requiring the newly formed society to hold at least one annual meeting which will include a session for the presentation of scientific papers. At the inaugural meeting the following officers were elected. *President*, Prof. J. G. Wood (Department of Botany, University of Adelaide), *Secretary*, Dr. L. H. May (Waite Agricultural Research Institute, Adelaide). *Treasurer*, Dr. L. G. Paleg (Waite Agricultural Research Institute, Adelaide), *Committee Members*, Dr. N. P. Kefford (A.C.T.), Mr. L. A. Thomas (Queensland), Dr. J. F. Turner (New South Wales), Dr. P. Brownell (South Australia), Dr. D. M. Paton (Tasmania), Dr. D. J. Carr (Victoria), Prof. B. J. Grieve (Western Australia).

Some scientific papers were also presented at the inaugural meeting, and these indicated the wide range of interests of Australian physiologists. Nitrogen metabolism and the mechanism of ion uptake by plant cells, which have long been under study in Adelaide and Sydney respectively, were discussed in the light of recent work. Growth regulators formed the basis of several papers, ranging from synthesis in a symbiotic association, effects in photoperiodic and vernalization responses, to their effects in root contraction. Translocation, plant cell structure, sodium nutrition and the dynamics of growth in seedlings were among other topics presented. Abstracts of all the papers will be published in the *Australian Journal of Science*. At the next meeting, to be held in Canberra, it is planned to include agronomic and horticultural topics of interest to plant physiologists.

Forests Products Research Laboratory

THE Council for Scientific and Industrial Research has set up the following Steering Committee to look after the research programme of the Forest Products Research Laboratory, in place of the Forest Products Research Board : Dr. B. K. Blount, deputy secretary of the Department of Scientific and Industrial Research (*chairman*) ; H. Douglass, a member of the Research Council and general secretary of the Iron and Steel Trades Confederation ; L. J. Cardew Wood, managing director of Bell's Asbestos and Engineering, Ltd., and director of Bell's Asbestos and Engineering (Holdings), Ltd. ; the director of the Forest Products Research Laboratory (Dr. F. Y. Henderson) ; H. Wooldridge, head of the Stations Division, Department of Scientific and Industrial Research. Its terms of reference are : (1) to be responsible to the Research Council for the selection of projects and for the allocation of effort to them, within the financial resources allocated to the Laboratory and such other limits as may from time to time be imposed by the Council ; (2) to report annually to Council, submitting a research programme for the following year. The Committee, which will be a full committee of the Research Council, is empowered to set up specialist sub-committees to provide technical advice on particular fields of work and especially on research in the field of pulping.

Future of Timber Research in the United Kingdom

FOLLOWING recent announcements of its policy on forest products research, the Council for Scientific and Industrial Research recommends that the ultimate objective should be to concentrate all timber research at Princes Risborough, the site of the present Forest Products Research Laboratory. This would avoid the danger of overlap and unnecessary expense that might arise if separate laboratories were developed in different localities to serve the sectional interests of the timber trade and would ensure that the most effective use is made of the qualified staff and material resources available in the various organizations concerned with timber research. Discussions are being held with the Timber Development Association and the Forestry Commission to determine the type of organization which would most effectively co-ordinate the research requirements of their interests. As an initial step to the achievement of this objective, the Department of Scientific and Industrial Research is discussing with the Timber Development Association the possibility that part of the Princes Risborough site might be made available to the Research and Development Committee of the Association for immediate development, without prejudice to work at present in hand at its existing laboratories. Discussions will shortly be held with other trade organizations interested in timber research.

Royal Observatory, Cape of Good Hope

IN his report for 1957 H.M. Astronomer at the Cape of Good Hope records continued progress in many branches of astronomy (pp. 9. Cape of Good Hope : The Observatory, 1958). On the administrative side the increase in the number of visiting astronomers from outside South Africa and the growing co-operation between the Cape and Radcliffe Observatories are both valuable developments. The routine work of the Cape Observatory is undoubtedly the most important, and in some fields it is the only work of its kind being done in the southern hemisphere. The meridian circle programme of observations of about seven thousand stars is approaching completion, and a new working list of faint stars for use as standards in photographic plate reductions is being prepared. The preparation for press of the "Cape Photographic Catalogue", zones −56° to −60° and −60° to −64°, has been completed; astrometric work on the zone −64° to −68° was completed in 1955 and the photometric work for this zone is almost finished. Position measurement for 4,400 stars in the −68° to −72° zone was completed, and proper motion and magnitude measurements are in progrsss. Preliminary work has been undertaken in all the remaining zones to the south celestial pole, involving 9,500 stars in all. A large programme of photoelectric photometry is under way with several telescopes. Magnitudes are being determined for many standard stars, stars on radial velocity programmes, parallax stars, stars in selected areas, comparison stars for cepheid variables, southern stars in the "Yale Bright Star Catalogue", and for other interesting objects. More than 7,000 observations were made during the year; more than 50,000 images were measured in a programme of photographic photometry, and other routine observations of the Sun, variable stars and occultations were continued. The radial velocity work at the Radcliffe Observatory was concerned with nearby stars, stars in the southern galactic cap and standard stars. Some miscellaneous observations were made on extragalactic nebulae, and the first section of the "Cape Photographic Atlas of Southern Galaxies" was published during the year.

Society of Protozoologists

The following elections have recently been made by the Society of Protozoologists: *President*, Dr. Elery R. Becker (Arizona State College); *Vice-President*, Dr. Norman D. Levine (University of Illinois); *Secretary*, Dr. John O. Corliss (University of Illinois); *Treasurer* (retained), Dr. Daniel M. Lilly (St. John's University, Jamaica, New York); *Editor* and *Acting Editor* of the *Journal of Protozoology* (both retained), Dr. William Trager (Rockefeller Institute) and Dr. Seymour H. Hutner (Haskins Laboratories, New York City); *Honorary Member*, Dr. Emmanuel Fauré-Fremiet (Collège de France, Paris). The Society will hold its next annual meeting with the American Institute of Biological Sciences in August 1959 at Pennsylvania State University.

The Night Sky in November

New moon occurs on Nov. 11d. 06h. 34m. U.T., and full moon on Nov. 26d. 10h. 16m. The following conjunctions with the Moon take place: Nov. 13d. 16h., Saturn 4° S.; Nov. 25d. 07h., Mars 3° N. In addition to these conjunctions with the Moon, Mercury is in conjunction with Antares on Nov. 11d. 12h., Mercury being 2·1° N. Mercury and Venus are too close to the Sun for observation. Mars rises at 17h. 25m., 16h. 05m. and 14h. 45m. at the beginning, middle and end of the month, respectively, setting on these dates at 8h. 55m., 7h. 30m. and 6h. 10m.; conditions for observation are very favourable. Mars reaches opposition on November 16, when its distance is 46 million miles and its stellar magnitude −2·0. Mars continues to retrograde, moving from Taurus into Aries on November 22. Jupiter is too close to the Sun for observation. Saturn may be visible low in the south-west after sunset, but conditions for observation are not favourable. Occultations brighter than magnitude 6 are as follows, observations being made at Greenwich: Nov. 2d. 02h. 17·1m., 26 Gem. (*R*); Nov. 3d. 01h. 43·4m., 68 Gem. (*R*); Nov. 27d. 20h. 58·6m., 115 Tau. (*R*); Nov. 29d. 23h. 05·0m., λ Gem. (*D*); Nov. 30d. 00h. 17·9m., λ Gem. (*R*). *R* and *D* refer to reappearance and disappearance, respectively. The Taurid meteors are active during the first fortnight of the month, conditions being favourable; the radiant is near R.A. 3h. 36m., Dec. +14°. The Leonid meteors are active on November 15–17, conditions being favourable; the radiant is near R.A. 10h. 08m., Dec. +22°.

Announcements

Mr. W. A. Dutton, assistant director of the Hosiery and Allied Trades' Research Association, Nottingham, and Mr. H. Marsden, Universal Winding Co., Ltd., Manchester, have been awarded the Institute Medal of the Textile Institute. This Medal was inaugurated in 1921 as an award by which recognition could be given for distinguished service to the textile industry in general and to the Institute in particular.

Trinity College, Cambridge, offers entrance exhibitions to male students of universities in the British Commonwealth to enable them to read for the degree of B.A., or LL.B., or for a diploma. Further information can be obtained from the Senior Tutor, Trinity College, Cambridge.

A conference on Electronic Digital Computers and their Industrial Applications will be held in the Department of Mathematics, Birmingham College of Technology, on December 10, when members of IBM, Ltd., will speak on the following topics: data processing machines available; commercial applications on IBM 650; technical applications including linear programming; organization and preparation for electronic data processing. During the course of the day, three 16-mm. sound films to illustrate IBM machines will be shown. The conference fee is £2, and further details and application forms can be had from the Registrar, College of Technology, Gosta Green, Birmingham 4.

The Faraday Society Bourke Lectures will be delivered by Prof. R. H. Stokes (University of New England, Australia). The lectures will be: "Tracer Diffusion and Self-diffusion in Concentrated Electrolytes", in the Main Lecture Theatre, Chemistry Department, King's College, Newcastle on Tyne, on November 14, at 5.30 p.m. (chairman: Prof. W. F. K. Wynne-Jones); and "The Relation between Ion Mobility and Viscosity in Aqueous Solutions", in the Chemistry Department, University of Glasgow, on November 18, at 4 p.m. (chairman: Prof. J. Monteath Robertson). The second lecture will also be given at the Edward Davies Chemical Laboratories, University College of Wales, Aberystwyth, on November 20, at 5.15 p.m. (chairman: Prof. C. W. Davies). Further information can be obtained from the Faraday Society, 6 Gray's Inn Square, London, W.C.1.

We regret that in referring to the appointment of Sir Rudolph Peters as president of the International Council of Scientific Unions (*Nature*, October 11, p. 990), he was wrongly described as lately director of the Agricultural Research Council Institute of Animal Physiology; Sir Rudolph is, in fact, head of the Biochemistry Department of the Institute.

Erratum. In the communication entitled "Stability of Evaporated Films", by M. Wyn Roberts, in *Nature* of October 25, p. 1151, par. 4, line 11, for "33×10^{-3} cm.^{3} (S.T.P.)" read "13×10^{-3} cm.^{3} (S.T.P.)".

THE CHEMICAL RESEARCH LABORATORY

REPORT FOR 1957

THE report of the Director of the Chemical Research Laboratory which accompanies the report of the Chemistry Research Board under the title "Chemistry Research, 1957"* is the last which will cover the work of the laboratory under that title, which has now been changed to the National Chemical Laboratory, and the Board itself was being disbanded on September 30 and replaced by a Steering Committee. The new unit at Harwell, which is to co-operate with the Atomic Energy Authority, is studying possible applications of radioisotopes and began work there on October 1, 1957. To permit extension of the programme carried out for the Authority on the extraction of radioactive elements from minerals and ores the Authority is extending the Radiochemical Building and increasing the staff engaged on its behalf. The Authority is also contributing to the intensification of work on chelating and complexing resins. After a critical review during the year of the scheme of providing standard organic compounds, the Board agreed that the charges made for pure standard samples should fully cover the cost of the service, and to economize scientific effort recommended that the preparation of standard materials should be limited to those not available by purchase elsewhere. The Board's report also emphasizes the urgent need to expand work in the inorganic field.

The Director's report notes the increased effort given during the year to the work on the extraction, concentration and purification of elements from ores and low-grade materials, the preparation of ion-exchange membranes and the synthesis of complexing resins. Among advances to which he directs particular attention are the construction of three experimental water-circulating systems to study the failure of tubes by corrosion, in water-circulating systems of modern engineering projects, and the development of an experimental technique to give reproducible results. The formation of an absorbed film and the subsequent growth of an oxide film have been followed by radiometric methods. A rapid method has been developed of concentrating the less plentiful constituents of rare-earth mixtures using a partial chromatographic technique, and further studies of zone-refining have shown that with tellurium, indium, tin and antimony the method is not effective in removing all the impurities as required by the electrical industry. The possibility of recovering germanium from ammoniacal liquor has also been examined. Advances are reported with resin-in-pulp and solvent extraction processes for extracting and recovering uranium and thorium from ores, and an ion-exchange phosphorylated cellulose has been developed for recovering thorium from sulphate solutions of monazite as well as a field method, which can be used by relatively unskilled personnel, for determining as little as 0·001 p.p.m. of uranium in river water.

The work of the Organic Group has included a new study of the synthesis and application of certain organo-metallic compounds with special reference to the preparation of materials of high thermal stability, further work on the isomerization of ethyl*cyclo*pentane, the reactions of nascent carbon-14, the rearrangement of dipotassium salicylate and hydrazine polymers and the polymerization of aromatic *iso*cyanates. Progress is reported in the purification and measurements work, including the construction of a high-voltage paper-electrophoresis apparatus and apparatus for the direct measurement of latent heats of vaporization and specific heats of vapours. Encouraging progress is also reported in the preparation of new types of ion-selective membranes, and cation- and anion-selective membranes based on polyvinyl chloride have shown very promising mechanical and electrochemical properties. In fractionating polymers it has been found that ^{14}C-labelled polysarcosine dimethyl amides of molecular weights up to about 12,000 can be separated by paper chromatography using gradient elution, and studies on the random partial sulphonation of cross-linked polystyrene promise to throw light on the fundamental mechanism of ion-exchange.

A comprehensive collection of organisms used in the assay of amino-acids was built up in the National Collection of Industrial Bacteria during the year. Pilot-plant trials of the microbial production of sulphur from sulphate-enriched sewage sludge in progress at the London County Council's Northern Outfall Works at Beckton have confirmed earlier laboratory experiments in that the final sludge 'dewaters' more efficiently than sludge digested from methane. The great reduction in the volume of solids for disposal and consequent saving in transport costs may have an important influence on the economics of the process. Other work by the Microbiology Group has been concerned with the microbial formation of methane and with the bacterial oxidation of aromatic compounds, including benzenesulphonic acid and catechol, and the perfusion apparatus described in the 1956 report has been used to satisfy requests from industry for organisms capable of destroying such recalcitrant chemicals as methylated and unmethylated aryl sulphonates, thiocyanates and β-naphthol.

The Chemical Engineering Group is studying the rate of solution of gases in agitated liquids and has devised an optical device for measuring the interfacial area in gas–liquid dispersions. It has also obtained valuable data on the evaluation of mass transfer coefficients.

About 10 per cent of the time of senior staff is occupied with advisory work, and at the end of the year the total staff, including 58 scientific officers, 86 experimental officers, 34 assistants (scientific) and 2 works technical officers, numbered 239 compared with 223 at the end of 1956. Appendixes list the staff in post on December 31, 1957, as well as the committees of the Board, patents publications during the year, standard samples of organic compounds and organisms deposited in the National Collection of Industrial Bacteria.

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* Department of Scientific and Industrial Research. Chemistry Research 1957: The Report of the Chemistry Research Board with the Report of the Director of the Chemical Research Laboratory. Pp. iv+96. (London: H.M. Stationery Office, 1958.) 5*s*. net.

SALT AND WATER BALANCE IN ANIMAL LIFE

THE mechanisms by which salt and water balance is maintained in the majority of the groups of cœlomate animals are now fairly well understood. Such mechanisms are of importance not only in all freshwater animals, which must always protect themselves against the continual loss of salts and the uptake of water, but also in many marine animals, where it is found that the salt and water content of the body is also carefully regulated. There are, however, many aspects of the functioning of these mechanisms about which very little is known at present. For example, salt balance is generally maintained by the activity of a specialized group of cells which are localized, often in the respiratory membranes, and which are capable of doing work to sustain a gradient of salt concentration across the membrane. Although the gross location of these cells can generally be inferred, we still have very little knowledge of their nature and properties at a cytological level. Histological and cytochemical studies under conditions of varying salt concentration can help in their identification and characterization.

The quantitative measurement of salt and water movements in animals is another important aspect which, as yet, has received little attention. It is only by such measurements that it is possible to discover the factors upon which these movements depend and the extent to which they can be regulated and controlled by the animal itself. The general availability of radioactive and other forms of tracer substances has now made this type of measurement much easier.

Both cytological and quantitative investigations of the mechanisms of salt and water balance in animals were considered in a symposium under the above title which was held as a joint session of Sections *D* and *I* (Zoology and Physiology and Biochemistry) at the British Association meeting at Glasgow on September 1.

Dr. T. Vickers (University of Cambridge) took up once again the question of the cells responsible for salt secretion in the teleost fish. Nearly thirty years ago Homer Smith showed that in the marine teleosts salt and water balance is achieved by the ingestion of large amounts of sea-water, the intestinal absorption of water and salts from this and the subsequent extrarenal excretion of the excess salt. Keys demonstrated that this salt was secreted by the gills, and Keys and Willmer identified large eosinophil cells in the branchial epithelium of the eel and suggested that these cells were responsible for salt secretion. Vickers showed that a similar type of cell appears in the gill lamellæ of the brackish- and fresh-water guppy, *Lebistes reticulatus*, when this is adapted to salt solutions. Under these conditions, small, previously undifferentiated cells are mobilized and they develop into large eosinophil cells the size of which depends on the salt load. They appear to be active cells with many mitochondria but give negative tests for mucus when fully developed. During the normal development of these cells they have small pits at their distal ends which are mucus-positive but which disappear as the cell enlarges. It is interesting that if the animal fails to adapt itself to the new salinity these pits enlarge and become filled with mucus, the cell cytoplasm becomes reduced and the cell now strongly resembles a normal goblet cell. It is clear that in this epithelium transformation from one functional cell type to another can take place. The primary stimulus for the formation of the salt-secreting cell is presumably the increase in salt load, but whether this can directly affect the branchial epithelium or whether the response is induced indirectly is not yet known.

That it is possible to induce a transformation of epithelial cells directly was demonstrated by Dr. H. B. Fell (University of Cambridge). She showed that vitamin A controls the differentiation of certain types of epithelia, the respiratory epithelium being especially susceptible. Thus, for example, the epithelium of the trachea is composed typically of columnar, ciliated and mucous cells. In the absence of vitamin A the ciliated and mucous cells disappear and a squamous epithelium is formed. The direct nature of this effect can be demonstrated by the behaviour of embryonic chick skin in tissue culture. A keratinizing epithelium of the squamous type is formed in a normal culture medium, but if vitamin A is present the keratin process is suppressed and the cells produce a mucous secretion. In some cases ciliated cells may also be produced. If the tissue is returned to the normal medium, after a few days of intensified secretion the basal cells proliferate and the squamous epithelium is regenerated.

Dr. R. Morris (University of Nottingham) showed that cell changes occurred in the respiratory epithelium of the river lamprey, *Petromyzon fluviatilis*, also. He described how the adult lampreys, which are found in the sea and in estuaries, come upstream to spawn and during the process lose their marine osmoregulatory mechanism, replacing it by a freshwater one. Animals taken from fresh water vary greatly in their behaviour in 33 per cent sea-water. Mature animals lose much water and their blood concentration rises to that of the outside solution. The fresh-run animals are very variable: some behave like mature animals, whereas others are able to maintain both salt and water balance. In the latter case, the mechanism closely resembles that found in the marine teleost and, in fact, the lampreys only differ in their greater water permeability. Just as in the marine teleost the gill epithelium contains salt-secreting cells, but its nature is variable. In many fresh-run animals the secreting cells are regressing and other cells, which are typical of the freshwater animals, are taking their place. The breakdown of the marine mechanism involves not only the disappearance of the secretory cells but also the loss of swallowing capacity as the animal ceases to feed in fresh water and the gut degenerates and there is an increase in permeability of the body surface.

The lampreys probably developed in fresh water and evolved their marine osmoregulatory mechanism quite independently of the teleosts.

The extent to which a knowledge of the mechanism of salt and water balance in the lower vertebrates, such as the cyclostomes and fishes, can assist in deducing the type of habitat in which the vertebrate group as a whole evolved was discussed by Dr. J. D. Robertson (University of Glasgow). A widely held view, due mainly to Homer Smith and Marshall, is that certain features of these mechanisms, especially the presence of the peculiar glomerular kidney, point to a freshwater origin for the vertebrates. Robertson challenged this view. He showed that the palæontological evidence indicates that the earliest vertebrates, the Ostracoderms and the Acanthodians, lived in the coastal waters of the sea, and their remains, found in the rocks of the Ordovician and Silurian periods, are mostly associated with known marine invertebrates. At the same time, geochemical evidence suggests that the seas in Ordovician times were probably almost as saline as they are to-day. Robertson claimed that the inferences which could be drawn from the physiological features of present-day vertebrates are not opposed to this view. He brought forward the fact that all non-vertebrate chordates are marine and their blood composition, where known, is similar to that of sea water. Although the salt content of the blood of almost all the aquatic vertebrates is much less than that of sea water, the blood of the myxinoid cyclostomes—a very primitive vertebrate group—is not dissimilar, and this may be a primary feature. Finally, he suggested that the glomerular kidney is not necessarily a freshwater adaptation. It may well have existed in marine protovertebrates as it does to-day in the marine elasmobranchs and myxinoids. In these marine animals the glomerular filtration surface may be practically as large as that of the freshwater teleosts.

There seems little to be gained by pursuing this question further until new facts have come to light. On the physiological side, many more studies on the quantitative aspects of renal function in the cyclostomes and fishes would do much to increase our knowledge on this fundamental issue.

A quantitative approach to the problems of salt balance was adopted by Dr. J. Shaw (King's College, Newcastle), who described an analysis of sodium uptake by the freshwater crayfish, *Astacus pallipes*. A steady state is achieved when the normal sodium loss is balanced by an equal uptake of sodium from the environment. The rate of sodium uptake can be conveniently measured by the use of a radioactive sodium isotope. The rate of sodium uptake depends on the external sodium concentration and a maximum rate is approached at concentrations as low as 1 m.mole/l. Above a certain minimum value balance can be achieved at any external concentration, since the uptake-rate is also regulated by the internal sodium concentration. A fall in the blood sodium concentration of 10 per cent or less may increase the rate of uptake by as much as five times. The system is a self-regulating one and results in the maintenance of the blood sodium concentration despite changes in the sodium content of the environment or the presence of other factors which may affect the sodium uptake-rate.

J. Shaw

AQUATIC AND AIR POLLUTION

A SYMPOSIUM on "The Effects of Pollution on Living Material", organized by the Institute of Biology, was held at the rooms of the Royal Geographical Society on September 25 and 26. The general and scientific interest in various aspects of this subject may be gauged from the fact that 380 registrations were received, more than a hundred of which were from industrial organizations, public authorities and similar bodies. The symposium was divided into four sessions, each dealing with one separate aspect of the problem: these were river, estuarine and air pollution, and pollution by radioactive substances.

In the field of air pollution the immediate need is clearly to study its effect on man, but there was evidence at this symposium that other aspects of the problem are not being neglected. Recent studies by Gorham[1] suggest that air pollution is increasing the concentrations of sulphuric acid in atmospheric precipitation in the Lake District and "will presumably hasten deterioration of already heavily leached Lake District soils". Moorland and high tarn communities may well be affected. Changes of this sort brought about by air pollution, though difficult to study except in local areas and special habitats, may be widespread.

Before about 1945 the biologist studying water pollution was primarily interested in the effects of polluting discharges on river and estuarine communities. The change in community structure often gave a useful measure of the severity of the pollution. The mode of action of the pollutants which resulted in such changes was rarely studied and, with the exception of organic pollution associated with low oxygen concentrations, practically no information was gathered on how these selective forces operated at organismic level. This state of affairs is generally true to-day, although a recent advance has been made concerning the chemical factors important in the distribution and deaths of fish in a sewage effluent channel[2].

Since the end of the Second World War, however, there has been an increasing interest in the effects of organisms on the polluted environment. In pollution by radioactive wastes, although there is no evidence of changes in community structure, the activity of organisms in accumulating and afterwards releasing radioisotopes is of the utmost importance in determining permissible discharges. In the field of 'conventional' water pollution similar trends are evident, and it seems likely, from the papers presented, that in the near future it will be possible to make estimates of some of the effects which organisms have on their environment.

The first speaker in the session concerning river pollution, Mr. F. T. K. Pentelow (Ministry of Agriculture, Fisheries and Food), began by admitting the difficulty of defining pollution. It could be said, however, that water is polluted when it becomes unfit for some use to which it could be put in its natural state. Mr. Pentelow directed attention to the many improvements which have occurred in British rivers over the past thirty years at a time of great industrial and urban expansion in spite of a major slump, rearmament, war, and a series of financial crises. Pollution, though now perhaps more widespread, is not nearly so intense as at the beginning of this period. Mr. Pentelow considered that an important factor leading to further improvement has been the recent formation of river boards and their endowment with statutory powers of control.

Mr. H. B. N. Hynes (University of Liverpool), discussing the biological effects of water pollution, suggested that the effects vary with the age of the phenomenon which the pollution produces. Man-made types of pollution, such as the discharge of poisons, which have no counterparts in natural ecological systems, result in an elimination of species, whereas other types, such as organic and thermal pollution, result in the development of replacement communities adapted to the peculiar ecological conditions. These observations seem to provide a useful basis for an ecological classification of pollutional effects. Dr. Hynes suggested that a controlled introduction of selected organisms tolerant of the somewhat higher temperatures found near discharges of cooling water from power stations might be considered. There are severe objections to such introductions, however, some of which were raised by the delegates present.

Mr. D. F. Westlake (Freshwater Biological Association) described recent studies made to assess some of the effects which plants and invertebrates have on stream conditions. It was shown that these organisms have quite large effects on the oxygen regime of organically polluted streams where high densities of bottom-living invertebrates and often large growths of macrophytic vegetation, especially *Cladophora*, occur. Estimates of these changes in the concentration of dissolved oxygen based on field observations were presented, together with descriptions of experimental studies of the effects of some invertebrates on bottom deposits. Physical effects of plant growth in streams were also discussed.

In the discussion which followed this session, Mr. F. W. Roberts (Luton Sewage Works) described his experiments on the effects of detergents on aquatic plants and reported that when grown in concentrations of 2·5 p.p.m. of anionic detergents, certain plants, such as *Ranunculus* and *Apium*, showed browning and loss of leaves. A non-ionic detergent did not have the same adverse effects. The tolerances of different plant species to detergents reflected their natural distribution in the river system with which he was concerned.

The second session, dealing with estuarine pollution, was introduced by Dr. B. A. Southgate (director, Water Pollution Research Laboratory), who said that British estuaries were generally in a worse condition than the rivers. He attributed this principally to differences in legislation and to past over-assessment of the capacity of estuaries to deal with pollution.

The first two speakers in this session, Mr. A. B. Wheatland and Mr. A. L. H. Gameson (Water Pollution Research Laboratory), discussed some aspects of the carbon, nitrogen and sulphur cycles in the Thames estuary. Mr. Wheatland described his investigations on denitrification and particularly the influence of low concentrations of dissolved oxygen and organic matter on this process. Some of the factors affecting the formation and oxidation of hydrogen sulphide were also described. Mr. Gameson discussed the importance of the biochemical reduction of nitrate and sulphate, and photosynthesis by phytoplankton, in contributing oxygen to the Thames Estuary. The reduction of nitrate produced about 140 tons of oxygen daily, that is, roughly one-quarter of that supplied by absorption from the atmosphere. Sulphate reduction and photosynthesis would seem to play a minor part in the oxygen balance of this estuary.

The final speaker on the first day, Prof. G. E. Newell (Queen Mary College, London), confining his remarks to lower estuaries, described the eutrofication resulting from organic pollution and its enrichment of the fauna and microflora. It was shown how hydrographic characteristics of estuarine basins and condition of the deposits may influence these pollutional effects.

In the discussion which followed, Mr. R. Bassindale (University of Bristol) showed how difficult it was to decide, in any given case, how far pollution was responsible for the reduction in fauna in the middle reaches of an estuary, for fluctuations in salinity in these areas result in a similar faunal reduction, and pollutional effects are generally superimposed on natural salinity effects.

The morning of September 26 was devoted to a series of papers on air pollution. The first speaker, Dr. E. T. Wilkins (Fuel Research Station), described the methods of measurement of deposited matter, sulphur dioxide, and smoke, and commented upon the value of the instruments employed for this purpose—now almost 3,000 in Great Britain—in monitoring suspected sources of excessive pollution and assessing local and national trends. Dr. Wilkins described measurements of toxic constituents of motor-vehicle exhausts, the most harmful of which appears to be carbon monoxide, which reaches concentrations of 50 p.p.m. at breathing height in London streets congested with traffic. The general conclusions of smog studies were outlined and possible synergistic effects of smoke, sulphuric acid and other complexes were discussed. The possibility of neutralizing acid gases in smog by the controlled addition of ammonia is being explored.

Dr. J. K. A. Bleasdale (National Vegetable Research Station) described his studies of the deleterious effects of air pollution on plant growth, these being particularly severe on winter annuals, which grow at a time when air pollution is at its worst. Dr. Bleasdale discussed the toxic effects of pollution on plants and soils and the effect of smoke haze in reducing light available for photosynthesis. The one redeeming feature in this otherwise gloomy picture is the notable freedom from certain fungal infections of plants growing in polluted air.

Dr. P. J. Lawther (Medical Research Council) pointed out that while acute air pollution is manifestly injurious and even fatal to old people and respiratory cripples, less dramatic consequences such as the hastening of the development of chronic bronchitis must not be overlooked. The chronic pollution suffered by town-dwellers is also suspected as an etiological factor in the production of chronic bronchitis and lung cancer, though in the case of the latter disease air pollution can play only a small part in the alarming increase in its prevalence.

Dr. R. Allcroft (Ministry of Agriculture, Fisheries and Food), reading a paper entitled "Fluorosis in Farm Animals", briefly surveyed the areas of occurrence and the industries with which it is associated. In Britain, fluorosis results exclusively from the aerial contamination of herbage by the emission of gases and dusts containing fluorine. The symptoms of fluorosis in cattle and other farm animals were described and shown on film, and the effects of dental changes and lameness, associated with fluorosis, on the quality of stock were discussed. Adverse environmental factors and physiological stresses greatly influence the severity of the toxic effect and it seems difficult to define damaging pasture concentrations, but a tolerance-level of between 30 and 50 p.p.m. in the food was given.

Mr. R. H. Burns (Atomic Energy Research Establishment), the first speaker in the final session, devoted to pollution by radioactive wastes, outlined the main differences between radioactive and other waste materials, the most important being our inability to destroy the harmful properties of the former by chemical means. Methods of dealing with wastes, disposal and storage, were described. There is an increasing demand for some of the fission products, particularly radiocæsium and radiostrontium, in industry and medicine, and storage of liquid wastes, though expensive, costing £200 per cubic metre, is being used on an increasing scale. Mr. Burns demonstrated by his paper how carefully such factors as the proper siting of effluent pipes and the fixing of permissible levels of discharge are considered in relation to the disposal of radioactive wastes.

Mr. W. L. Templeton (U.K. Atomic Energy Authority) directed attention to the greater hazards that may arise from accumulation of radioactive isotopes from the diluting medium by food-organisms than by direct radiation from the environment. The value of the observational and experimental approaches in the measurement of accumulation factors was outlined and their findings surveyed. Mr. Templeton felt, however, that series of planned experimental discharges, each of several months duration, would be of the greatest value in determining long-term variations and build-up of activity.

Dr. H. J. M. Bowen (Wantage Radiation Laboratory), discussing the uptake of fission products by plants, outlined recent advances in our knowledge of their absorption by various plant structures and their translocation in plant tissues. Dr. Bowen described his work with accumulator plants, that is, plants which concentrate large quantities of specific elements. He found that radiostrontium, the most dangerous fission product, was accumulated particularly by certain species of *Fucus* and *Laminaria*. It would seem that one important gap in our knowledge is that of the relation of rainfall and soil-type to the accumulation of fission products by plants.

In the last paper of the symposium, entitled "Genetic Hazards of Radioactive Pollution", Dr. T. C. Carter (Medical Research Council) suggested that recent work casts doubt on assumptions made by experimental geneticists, based principally on the radiation effects on gene mutation in *Drosophila* sperms. It is on these questionable assumptions that radiation effects are calculated. Dr. Carter stressed the need for an investigation of the relation between rates of mutation and accumulated radiation doses in mammals, particularly in the low-dosage range relevant to man. All present-day assessments of genetic hazards of radiation assume a linear relation. A figure of about £200,000 was quoted as the total outlay necessary for such an investigation. This is surely a small price to pay for such basic and vital information, especially when man's future well-being is at stake.

R. W. Edwards

[1] Gorham, E., *Trans. Roy. Soc.*, B, 241, 147 (1958).

[2] Allan, I. R. H., Herbert, D. W. M., and Alabaster, J. S., *Fish. Invest.*, 6, No. 2 (1958).

THE UNIVERSITY GRANTS COMMITTEE

RETURNS FOR 1956–57

THE annual returns from universities and university colleges in receipt of Treasury grants for the academic year 1956–57, published by the University Grants Committee*, records a further increase of 4,672 in the number of full-time students, which now stands at 89,866, compared with 81,705 in 1954–55, and it is expected that the number in 1957–58 will show a greater increase since the number of full-time students in the autumn term of 1957 was 5,899 greater than in the autumn term of 1955. There were 6,115 full-time and 2,016 part-time students from overseas within the British Commonwealth and 3,792 full-time and 1,756 part-time students from foreign countries; for 1955–56 the corresponding figures were 5,536 and 2,068 for the Commonwealth and 3,750 and 1,756 for foreign countries. Distribution of full-time students among the faculties showed no significant change, but the proportion in pure science increased from 21·3 to 22·2 per cent, in technology from 13·3 to 13·9 per cent, and that in medicine decreased from 15·7 to 14·4 per cent. Full-time advanced students of pure science numbered 3,675 (35 per cent); of technology 1,650 (15·7 per cent); and medicine and dentistry 1,041 (9·9 per cent); 2,870 students were working for the teacher's diploma. Of the full-time students, 71,713 were reading for a first degree, 3,969 for a first diploma, and 13,379 engaged in research or other advanced work, the corresponding figures for 1955–56 being 67,850, 4,021 and 12,668.

The proportion of assisted students was 75·7 per cent compared with 74·9 per cent in 1955–56 and 71·9 per cent in 1953–54, ranging from 90·4 per cent in Wales, 83·8 per cent for English universities and university colleges, excluding Oxford, Cambridge and London, to 61·7 per cent for Scotland. Of the recurrent income of £41,635,609 (an increase of £3,338,958 on 1955–56), £29,082,526 was from parliamentary grants (69·8 per cent). Income from fees decreased from 11·2 to 10·8 per cent, local authority grants increased from 2·9 to 3·1 per cent, payments for research from 6·0 to 6·5 per cent, gifts and subscriptions from 1·0 to 1·2 per cent, and endowments were again 4·0 per cent. Full-time teaching staff increased to 10,485, compared with 10,202 in 1955–56 and 9,810 in 1954–55.

The proportion of full-time students residing in colleges and halls of residence was 27·4 per cent, compared with 27·5 in 1955–56, but the total, 24,652, was higher. The proportion of men in residence was 23·2 per cent and of women 39·9 per cent; whereas 41,291 (46·0 per cent) were in lodgings and 23,923 (26·6 per cent) at home, compared with 44·7 per cent and 27·8 per cent, respectively, in the previous year. Non-recurrent grants in respect of capital expenditure totalled £9,134,185, compared with £7,084,366 in 1955–56, and of the recurrent expenditure of £41,509,703—an increase of 9·1 per cent on 1955–56 —7·0 per cent was spent on administration, 68·4 per cent on departmental maintenance, and 12·9 per cent on maintenance of premises. The largest increases were in rates, insurance, heat, light, water, wages, etc. (15·3 per cent), departmental wages (technicians and laboratory assistants) (14 per cent), and in repairs and maintenance of buildings (13·9 per cent). Expenditure on libraries (excluding general maintenance, rates, etc.) increased from £1,468,512 to £1,620,958 but remained at 3·9 per cent of the total.

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* University Grants Committee. Returns from Universities and University Colleges in receipt of Treasury Grant, Academic Year 1956–1957. Pp. 50. (Cmnd. 477.) (London: H.M. Stationery Office, 1958.) 4*s*. net.

SCIENTIFIC FILMS AT THE BRITISH ASSOCIATION

FOR the fourth successive year the Scientific and Technical Group of the Royal Photographic Society of Great Britain, in conjunction with the Scientific Films Committee of the British Association, presented a series of research films as part of the annual meeting of the British Association. These films were shown in two sessions during the morning and afternoon of August 30. The morning session was under the chairmanship of Sir Raymond Priestley, and during the afternoon Mr. Bowler, vice-president of the Society, took the chair.

Several films were devoted to biological subjects, from the study of the mating behaviour of marsupial frogs to the investigation of cancerous cells. The muscle structure of sea-anemones, courtship of *Drosophila melanogaster*, nematodes and *Leishmania donovani* were also objects of investigation. In what might be described as the industrial field many problems have been covered with ciné techniques, including the casting of steel, coke-oven performance, vehicle suspension systems, flooring research, bookbinding operations and the flow of water in large pipes.

From the psychological aspect, two films were shown which demonstrated techniques that have been employed to identify the particular point of a general scene at which a subject is looking, thus enabling eye co-ordination to be studied. Also in this field an extract was shown from a film which studied parent/child relationship in an experimental treatment of the problems involved in admission to hospital of children under school age.

In pure physics, the motion of electrons in electric fields was demonstrated by means of charged droplets; this film was made in Germany. Automatic self-replication was also shown by ingenious systems of models. Finally, Mr. Hallett, secretary of the Society, gave a short talk on the scope and aims of the "Encyclopædia Cinematographica", with examples of research films loaned by Dr. Wolf, of Göttingen.

Among the methods used to prepare these films were time-lapse and high-speed ciné-photography, interference and phase-contrast microscopy, electron microscopy and television techniques. Colour and monochrome, silent and sound-track films were all represented at this meeting, which admirably demonstrated the wide variety of ways in which photography can be of use in research in an equally wide range of scientific investigation.

A more detailed report will be published in the *Journal of Photographic Science.*

A STRUCTURAL THEORY FOR METAL ALKOXIDE POLYMERS

By DR. D. C. BRADLEY
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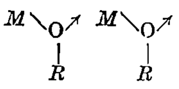
RECENT studies[1,2] on the metal alkoxides $M(OR)_n$, where M is an n-valent metal and R is an alkyl group, have established that derivatives with the lower primary or secondary alkyl groups are in fact polymeric, that is $\{M(OR)_n\}_x$, where x is the degree of polymerization. It is believed that this polymerization is caused by intermolecular bonds involving the metal and oxygen atoms, namely:



and is a manifestation of the tendency of the metal to expand its covalency by co-ordination with oxygen. It is a striking feature of the metal alkoxides that the alternative mechanism for this covalency expansion, namely, co-ordination between the alkoxide and a ligand containing oxygen or nitrogen (for example, $M(OR)_n,xL$), is relatively rare and this suggests a special stability for the polymer. Moreover, it is a general rule that, in a series of metal alkoxides with metals of the same sub-group (for example, titanium, zirconium, thorium) and having the same alkyl groups, the degree of polymerization x increases with the size of the metal atom. Nevertheless, only in a few cases have structures been suggested for metal alkoxide polymers[3-7]. Another interesting feature of these compounds is that the polymers are relatively small compared with typical organic polymers and silicones. Recent studies on the hydrolysis of titanium alkoxides[8,9] showed that the titanium oxide alkoxides $TiO_h(OR)_{4-2h}$ formed were also low polymers, and this behaviour was explained in terms of a series of structural models in which titanium was 6-co-ordinated by oxygen. Further consideration of these structures reveals that in each case the degree of polymerization is unique in being the lowest possible, and this led me to explore the possibility of rationalizing the polymeric nature of metal alkoxides in terms of the stereochemistry of the metal. It is the purpose of this article to show that a rationalization can indeed be achieved on the basis of the following single new major assumption. It is assumed that the metal alkoxide adopts the smallest possible structural unit consistent with all the metal atoms attaining a higher co-ordination number. Also the choice of structure is limited by the condition that the co-ordination number of oxygen does not exceed

Table 1

Compound	Co-ordination No. of M	Stereochemistry of M	Minimum degree of polymer-ization
MOR	2	$OMO = 90°$	2
	2	$OMO = 120°$	3
	3	Pyramidal	4*
$M(OR)_2$	3	Planar, one $OMO = 90°$	2
	3	Planar, $OMO = 120°$	3
	4	Tetrahedral	3
	4	Planar	4
	6	Octahedral	Infinite 3-dimensional polymer
$M(OR)_3$	4	Tetrahedral	2*
	4	Planar	2
	6	Octahedral	8*
$M(OR)_4$	5	Trigonal bipyramidal	2
	6	Octahedral	3*
	8	Cubic	8
$M(OR)_5$	6	Octahedral	2*
	8	Cubic	4
$M(OR)_6$	8	Cubic	2*

* Agrees exactly with predictions of the theory

four. Then the degree of polymerization can be predicted in terms of the stereochemistry of the metal. Some typical deductions from this theory are given in Table 1 and it is clear that in general the polymers predicted are very low ones. Next we shall see how far the experimental evidence supports this theory. Unfortunately there are to date no direct structural determinations available on metal alkoxides and we can only compare the predicted degree of polymerization with that determined cryoscopically or ebullioscopically, bearing in mind that these experimental values are averages.

Univalent Metal Alkoxides

Sidgwick and Sutton[3] found that thallous alkoxides were tetrameric and proposed a structure in which each thallium atom was bonded pyramidally to three oxygens and each oxygen was bonded to three thalliums and one alkyl group. This agrees exactly with the above theoretical considerations. No other data are available on univalent metal alkoxides. The alkali metal alkoxides are usually assumed to be ionic, but in view of the covalent nature of alkali metal zirconium ennea-alkoxides[10] there is the possibility that the alkali metals, especially lithium, may form covalent alkoxides. Similarly, it will be worth while to investigate cuprous, argentous and aurous alkoxides.

Bivalent Metal Alkoxides

No data are available on bivalent metal alkoxides although some have been prepared. The case of beryllium is particularly interesting because it is expected to adopt a tetrahedral configuration with oxygen and should thus form trimeric dialkoxides with the structure already proposed[2]. On the other hand, 4-co-ordinated bivalent copper might adopt the planar configuration resulting in cyclic tetrameric cupric alkoxides. A cyclic trimer is unlikely because this would bring the copper atoms too close together.

Tervalent Metal Alkoxides

Aluminium alkoxides are well known and some molecular weights have been determined[4,11,12]. Robinson and Peak[4] proposed a structure for the tetrameric alkoxides involving a cyclic system with 4-co-ordinated aluminium. However, the above theory predicts a dimer for 4-co-ordinated tetrahedral aluminium and there is no obvious reason why a cyclic tetramer should obtain. On the other hand, it is known that aluminium can achieve a maximum co-ordination number of six and for octahedral aluminium the theory predicts an octamer. Thus the tetramers could result from a distribution of the aluminium between 4- and 6-co-ordination.

In fact, the possibility of two higher co-ordination numbers for aluminium is probably the cause of the unusual behaviour of aluminium trialkoxides. For example, Mehrotra[12] has demonstrated an 'ageing effect' in which the degree of polymerization increases with time. Also, a hysteresis effect has been detected in measuring the vapour pressures of aluminium alkoxides[13]. In addition, Mehrotra[12] found that aluminium *iso*propoxide was dimeric in the vapour state. These facts can readily be interpreted on the basis of the structural theory. Assuming that the freshly distilled or sublimed alkoxide is initially dimeric and contains tetrahedral aluminium, then the ageing effect will be due to a structural rearrangement as the aluminium realizes its maximum co-ordination number. Clearly, this rearrangement in a solid at room temperature will be slow and consequently the degree of polymerization of an aluminium alkoxide will depend on its previous history. This could explain the high values reported by Ulich and Nespital[11]. Although the theory predicts the dimer and the octamer for 4- and 6-co-ordinated aluminium, respectively, other unique structures are predicted for systems involving both higher co-ordination numbers. For example, if 75 per cent is 4-co-ordinate and 25 per cent 6-co-ordinate, a tetramer is possible containing a central octahedral aluminium attached through alkoxide bridges to the three tetrahedral aluminiums[2]. This corresponds to the completion of the first distinct stage in the ageing process and it is extremely interesting to note that Robinson and Peak and Mehrotra found tetrameric aluminium alkoxides. The remaining unique structure is a hexamer involving 66·7 per cent 4-co-ordinate and 33·3 per cent 6-co-ordinate aluminium. In this structure[2] the molecule contains two 6-octahedral aluminiums joined through an alkoxide bridge and each one is attached through alkoxide bridges to two tetrahedral aluminiums. The second stage in the ageing process should then result in the formation of this hexamer and the final stage would involve the formation of octamers in which the aluminium is entirely 6-co-ordinated.

Quadrivalent Metal Alkoxides

Titanium tetra-alkoxides have been known for many years, but the first results of structural significance were reported by Caughlan *et al.*[5], who found that these compounds tended to a limiting degree of polymerization of 3 at higher concentrations. They proposed a structure for the trimer (Fig. 1) based on 6-co-ordinated titanium with three octahedra joined together through the sharing of common faces. As can be seen from Table 1, this trimeric structure is in accordance with the predictions of the theory. Even more striking examples of structures which are logical consequences of this theory are the titanium oxide ethoxides $Ti_6O_4(OEt)_{16}$ (Fig. 2) and[8] $Ti_{12}O_{12}(OEt)_{24}$. Although titanium appears limited to a maximum co-ordination number of 6, zirconium, cerium-IV and thorium can achieve a higher co-ordination number of 8. The lowest possible polymer for a tetra-alkoxide containing 8-co-ordinated metal is the octamer involving a cyclic configuration of body-centred cubes (Fig. 3)[14]. The cube was chosen for 8-co-ordination because there are four oxygens on each face and this gives the maximum degree of sharing of alkoxide groups between any two adjacent metal atoms and hence the minimum degree of polymerization. Zirconium normal alkoxides[6] had an average degree of polymerization of 3·5, which is near the predicted value for 6-co-ordinated zirconium. Moreover, zirconium tetra-*iso*propoxide is trimeric and it forms a solvate $Zr(OPr^i)_4,Pr^iOH$, which is dimeric. A structure was proposed for the solvate[6] involving octahedrally 6-co-ordinated zirconium (Fig. 4) and it is interesting to note that this is exactly in accordance with the structural theory. The lower alkoxides of thorium were insoluble, thus precluding molecular weight determinations, but the longer chain normal alkoxides were soluble and exhibited an average degree of polymerization of 6·3, which suggests that the thorium is predominantly 8-co-ordinated. In view of the availability of two higher co-ordination numbers for zirconium, cerium-IV and thorium, it would not be surprising to find ageing effects in their alkoxides (cf. aluminium).

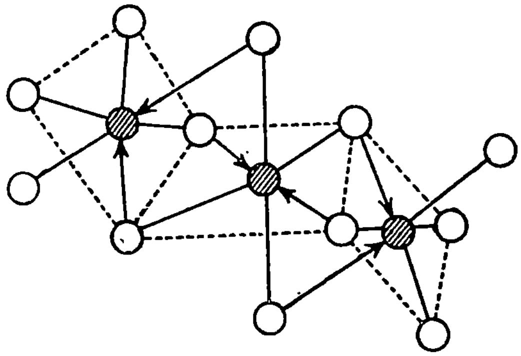


Fig. 1. $Ti_3(OEt)_{12}$. ●, Ti; ○, O in O*Et*

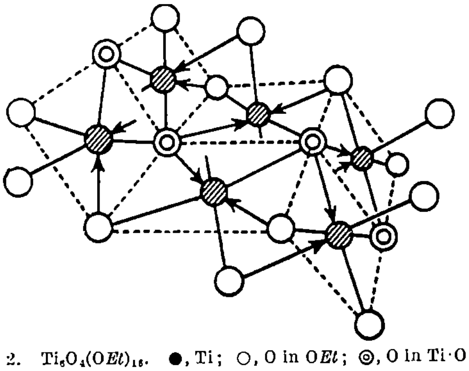


Fig. 2. $Ti_6O_4(OEt)_{16}$. ●, Ti; ○, O in O*Et*; ◎, O in Ti·O·Ti

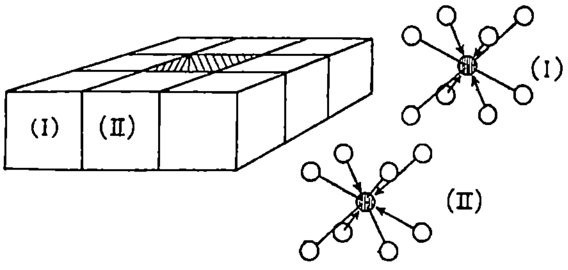


Fig. 3. Structure of $M_8(OR)_{32}$. ●, *M*; ○, O in O*R*

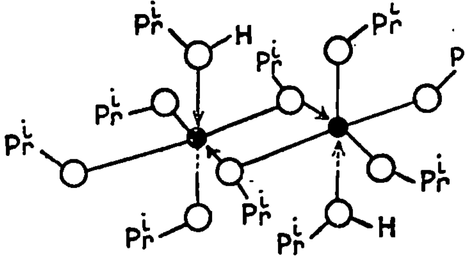


Fig. 4. ●, Zirconium; ○, Oxygen

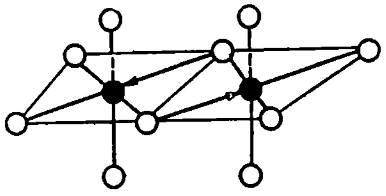


Fig. 5. ●, Tantalum; ○, Oxygen

Quinquevalent Metal Alkoxides

It can be seen from Table 1 that a penta-alkoxide containing an octahedrally 6-co-ordinated metal should be dimeric. Recent work on normal alkoxides of niobium[15] and tantalum[7] showed that they were dimeric and a structure was proposed for the tantalum derivatives in agreement with the theory (Fig. 5). Moreover, a number of uranium penta-alkoxides were also found to be dimeric but the penta methoxide $U(OMe)_5$ was trimeric and it was suggested that in the latter there might be a significant proportion of 8-co-ordinated uranium[15]. Thus the smallest polymer for a penta-alkoxide containing an 8-co-ordinated metal with the cubic configuration would be the tetramer. A tetramer will also result from a square antiprism configuration.

Sexavalent Metal Alkoxides

The theory predicts a dimeric state for a hexa-alkoxide containing an 8-co-ordinated metal with either the cubic body-centred or square antiprism configuration. Measurements on uranium hexamethoxide $U(OMe)_6$ show that it is predominantly dimeric (Bradley, D. C., and Chatterjee, A. K., unpublished work), suggesting that the uranium is 8-co-ordinated.

This survey of experimental data has shown several examples (Table 1) which agree exactly with the predictions of the theory and other cases where the known degree of polymerization is within the limits set by the theory (that is, where more than one higher co-ordination number is available). The variety of examples which fit the theory make it unlikely that the agreement is merely coincidental. Therefore it is interesting to consider why metal alkoxides adopt the structures with the lowest degrees of polymerization and to discover whether this phenomenon is shared with other types of compound. Undoubtedly a factor of fundamental importance is the covalency expansion of the metal, since this causes the polymerization. Thus in the formation of organic high polymers, no change in covalency of carbon is involved, and similarly in the silicones the silicon is essentially quadricovalent although some π-bonding involving 3*d* orbitals of the silicon may contribute to the structure. Another important feature of the metal alkoxides is the relatively low energy (about 10 kcal.) of the intermolecular bonds which hold the polymer together. Clearly the most stable polymer (to thermal dissociation) will be the one containing the maximum number of these weak intermolecular bonds between adjacent units in the polymer. This point can well be illustrated by reference to titanium alkoxides. If all the titanium is octahedrally 6-co-ordinated there is a choice between the trimer in which the octahedra share faces and each unit is held by three intermolecular bonds, and a higher polymer in which the octahedra share edges and each unit is held by two intermolecular bonds. If the intermolecular bond energy is approximately the same in each case, then 50 per cent more energy is required to detach a unit from the trimer molecule than from the higher polymer. According to these ideas the formation of low polymers need not be limited to the metal alkoxides but could be expected wherever the formation of a polymer is due to covalency expansion of an element and wherein the intermolecular bonds are weak. For example, some of the electron-deficient molecules such as the boron hydrides and metal alkyls support this view. Diborane is formed from BH_3 because the tercovalent boron increases its covalency to four. This covalency expansion could be achieved in an infinite linear polymer $(BH_3)_\infty$ in which each unit of the polymer is held by only one hydrogen bridge as against the two in diborane. However, it must be realized that in some systems of inorganic polymers (for example, borazoles and phosphonitrilic compounds) also involving covalency expansion there are other complicating factors such as π-bonding and aromaticity which may stabilize particular structures, and it does not follow that the molecule will adopt the lowest possible degree of polymerization.

It is hoped to test the theory discussed above by direct structural measurements on the metal alkoxides. However, it is always possible that in the crystal lattice a metal alkoxide may adopt a degree of polymerization different from that exhibited in solution.

I am indebted to the Chemical Society for permission to reproduce the diagrams in Figs. 1–5, and also to Prof. W. Wardlaw for his guidance and encouragement throughout this work.

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EYE MOVEMENTS AND THE STABILITY OF THE VISUAL WORLD

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THE visual perception of movement is generally regarded as of primary biological importance, yet far less work has been done on this subject than on topics such as colour vision, visual acuity and the photic sensitivity of the eye. Further, surprisingly little is reliably known about the neurological mechanisms subserving movement perception. There are many unsettled questions, in particular that of the apparent stability of the visual world during voluntary movements of the eye. Some of the problems raised by the visual perception of movement will be discussed in this article.

Information Channels in the Perception of Movement

The simplest case of movement perception is that given by a moving self-luminous object in a dark room. Perception of its movement may occur under two different sets of conditions: (1) the eyes may follow the object ('tracking'), in which case its image will, ideally, remain stationary upon the retinæ; and (2) the eyes may remain stationary so that the images travel across the retinæ. Since movement is experienced under both conditions, there must be at least two information channels subserving movement perception. The first involves tracking eye movements, and may be called the 'retina/head' system. The second involves shifts of the image across the retina, and may be called the 'image/retina' system. It may be supposed that the two systems are based on essentially different neurological mechanisms.

Movement perceptions may, in special circumstances, be paradoxical. When a fast-flowing river, the view from a moving train, or an endless belt of black-and-white stripes is fixated for several seconds it will be found that if the gaze is transferred to a stationary object it will seem to move in the opposite direction and with corresponding velocities to those of the previously observed real movement. This after-effect of movement is paradoxical, for though movement is clearly observed it may also be seen that nothing is changing in position. Similarly, when a stationary small weak light is observed in total darkness it will seem to move erratically, and yet it may not seem to change its position to any marked extent. Such paradoxical perceptions may be due to incompatible information arriving from the two or more movement channels. Adaptation or random changes in the systems might be the cause.

As is well known, there are two essentially different types of eye movement, first studied systematically by

Dodge[1,2]. When the eye tracks a moving target, once it is 'locked' on to the target it moves smoothly, provided that the target moves in a simple, known manner without excessive changes in direction or velocity. Voluntary movements in the absence of a target take place in small jerks ('saccades') occurring about four times per second, which have been much studied particularly in relation to reading.

It is generally supposed that smooth tracking movements of the eyes occur only in response to retinal cues, that is they form part of what we have called the 'retina/head' system. I have shown that this is not necessarily the case. A small neon lamp is arranged to flash at 25–50 flashes/sec.: the light will appear continuous under conditions of steady fixation, but if, with the eyes remaining still, the lamp is moved steadily across the retina, a regular flicker will be noticed. This is a well-known effect. If now the eye is swept as smoothly as possible by voluntary movement, this regular flicker is not seen. The lamp seems to move in jerks. Evidently the saccadic movements prevent the smooth travel of the image which is necessary for the observation of the regular flicker. On the other hand, when the eyes follow a moving target the flicker may be observed, as when the lamp is moved across the field with the eyes stationary. Using this technique, I have been able to show that it is not necessary for the observer to track a visual object for the smooth eye movements to occur. The regular flicker indicating smooth eye movements may be seen if the observer tries to track his own hand under conditions of complete darkness apart from the light from the neon lamp, his hand being invisible. That is to say, smooth eye movements may be elicited even in the absence of appropriate retinal stimuli. It follows that the retina/head system may involve a proprioceptive component; information from moving members of the body may suffice to actuate the smooth eye movement system. I have also found that the apparent movements of a stationary small weak light viewed in darkness (the 'autokinetic effect') are influenced by slight unbalanced strains imposed on the eye or neck musculature. The effect may normally be due to randomly occurring imbalance of the musculature or proprioceptive systems of the eye and neck.

Eye Movements and Perceptual Stability

It is a commonplace to state that when the eyes move voluntarily across an extended field (by means of saccadic movements) there is little, if any, change in apparent position of the perceived objects. The visual world does not swing round in the direction opposed to the eye movement. On the other hand, nearly all subjects report that when an object moving across the field is tracked, the stationary background does tend to swing round in the opposed direction. The experience is similar to, though probably less marked than, the movement of the field observed when the eye-ball is moved passively by pressure from the finger. This observation suggests that saccadic eye movements are in some way necessary for the stability of the visual world. It may be that the jerky movements of the eye are themselves important, or that the saccadic mechanism accepts information giving rise to stability which is rejected during smooth tracking movements. Evidence to be given below suggests that the former is the case.

The problem of the stability of the visual world was discussed by Helmholtz[3], and later by many other writers, the most recent being Mackay[4]. There have been two main theories. The first, that stabilization is given by proprioceptive information from the extrinsic eye muscles, which has been called the 'inflow' theory, was rejected by Helmholtz, who held that the central command signals (but called by him 'the Will') are monitored by an internal loop which gives appropriate information for providing stability, provided the motor system is functional. This has been called the 'outflow' theory. He pointed out that patients suffering from paralysis of the external recti, and who were therefore unable to execute voluntary eye movements, experience the visual world moving round in the direction in which the eyes should have moved had it been possible to "execute the command". This observation has been confirmed under more controlled conditions[5].

A useful technique for investigating many of the phenomena of stabilization and movement perception is provided by observations of after-images (preferably produced by fixating a photographic-type electronic flash tube) under various conditions. It is not always realized that after-images observed in complete darkness move, apparently rather precisely, with the eyes during slow voluntary eye movements though they are not affected by passive movements. We should expect some feed-back from the stretch receptors which are now known to exist in the eye muscles[6,7] during passive movements, and this should produce some shift of after-images if the inflow theory were true.

We find that if, in total darkness, the drift of an after-image is observed during (*a*) slow voluntary eye movements, and (*b*) during the 'proprioceptive tracking' of the observer's hand described above, the after-image shows small saccadic-like jerks in condition (*a*), but not in condition (*b*), when it moves smoothly. If the velocity of the hand movement is changed the after-image may seem to lead or lag, and then to 'lock' on to the proprioceptive locus of the hand. The jerks experienced in condition (*a*) suggest that the stabilizing system has access to information of saccadic movements.

The Cancellation Theory

Helmholtz does not clearly state how his outflowing command signals are supposed to produce stability. Since stability depends upon the eyes in fact moving, the shift of the retinal image must be important. The term 'outflow' theory is thus misleading, for it ignores this shift of the retinal image and the information it transmits. Passive eye movements produce marked contrary shifts of the visual world: Helmholtz's theory requires these movement signals in conjunction with his command signals to produce stabilization, and this should be stated explicitly. The 'outflow' theory may, in this form, be called the 'cancellation' theory, where signals from the eye/head system are supposed to be cancelled out by signals from the image/retina system. This is similar to the view put forward by von Holst[8], but is really a natural extension of Helmholtz's theory.

Mackay[4] has recently made the interesting suggestion that stabilization is not something which is achieved, but rather that things are regarded as stable unless there is sufficient evidence to the contrary. Thus he says: "what requires informational justification is not the maintenance of stability but the perception of change", and also: "the retinal changes resulting from voluntary movement evoke no perception of world-motion, because they are not an awkward consequence to be compensated, but part of the goal to be achieved". He explains the apparent movement of the perceptual world when the eye movements are paralysed by saying that the 'goal' (which is internal and conceptual) shifts with changing expectations. This may be contrasted with the cancellation of the command signals by retinal movement information.

On the 'cancellation' theory the world moves if the eye movement is thwarted because the command signal is not cancelled by the image/retina system, there being no signal. Similarly, after-images move during voluntary eye movements, because there is no shift of the image across the retina to give an image/retina signal.

On the 'cancellation' theory we may predict that if we could destroy movement information in the image/retina system then the visual world should seem to move with the eye during voluntary eye movements. This may be done simply by illuminating the field with a stroboscope set to 4–5 flashes/sec. Movement is then only seen when the eye follows an object. With the eyes stationary, a moving object is observed to occupy successive positions, but not to move. When it is tracked it does, however, in stroboscopic illumination, appear to move. Voluntary eye movements produce loss of stability; the entire visual field moves in jerks. If now smooth eye movements are produced, by tracking a small self-luminous object held rather close to the eye, the entire visual world may be seen to move with the tracking object, and therefore with the eyes. This is observed best with a faintly glowing filament mounted on a pendulum bob; the visual world then swings with the bob, provided the distance and velocity conditions are appropriate.

This is difficult to reconcile with Mackay's 'null hypothesis' view of the matter, for the expectation of movement can scarcely be supposed to be related to the manner of illumination or to the kind of movement of the eye.

Mackay's observation that a stationary glowing filament moves though the stroboscopically lit field remains relatively stable during passive eye movements would be expected on the 'cancellation' hypothesis, for the image/retina system should give movement information from the self-luminous filament only, and the eye/head system will give no information. The new observation given here, that the visual world moves with the eyes under these conditions when following a target, seems to be positive evidence for the cancellation hypothesis.

It may be suggested that saccadic movements are important in providing large movement signals which may be readily computed to give cancellation.

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BETA-PROPIOLACTONE AS A TOXOIDING AGENT

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THE conversion of a bacterial exotoxin into a non-toxic antigen suitable for injection into animals presents special difficulties in the case of an unstable substance such as the β-toxin of *Cl. welchii* Types *B* and *C*. This antigen, which is used for vaccinating domestic animals against enterotoxæmia, deteriorates rapidly[1,2], even at 4° C.

The usual method of toxoiding β-toxin for vaccine preparation involves incubating the culture filtrates with formalin at 37° C. until the material is no longer lethal for mice. Culture filtrates with initial minimum mouse lethal doses of 0·005–0·001 ml. normally require 9–21 days to become non-toxic. More concentrated solutions of β-toxin, prepared by ammonium sulphate precipitation or by freeze-drying of the culture filtrates, take proportionately longer.

The antigenic potency of these vaccines is tested in rabbits as follows: two doses of 2 ml. each of the inactivated preparations to which alum is added to a final concentration of 1·0 per cent are injected. There is an interval of four weeks between the two injections and the rabbits are bled two weeks later. The antibody contents of sera obtained in this manner from about ninety rabbits used for testing twelve batches of formalin-inactivated culture filtrate averaged 7·58 international β-antitoxin units/ml. Seventeen batches of formalin-inactivated Type *B* culture were tested by the procedure recommended in the British Veterinary Codex for Lamb Dysentery Vaccine and the antibody contents from the rabbit sera averaged 2·75 international β-antitoxin units/ml. (the minimal response for this vaccine should be 2·5 international β-antitoxin units/ml.).

A concentrated Type *C* filtrate (minimum mouse lethal dose, 0·0002 ml.) was used for comparing the toxoiding properties of β-propiolactone with that of formalin. The final concentrations of β-propiolactone used were 0·3, 0·6, 0·9 and 1·0 per cent (v/v); formalin concentrations were 0·6 and 3·0 per cent. The β-propiolactone was added as a chilled, freshly prepared 10 per cent (v/v) aqueous solution and the mixtures were buffered with 0·5 *M* disodium hydrogen phosphate. Formalin was added as a 40 per cent solution of formaldehyde without buffering. The reactions with β-propiolactone were complete after 2 hr. incubation at 37° C., when no more acid decomposition products were formed. The mixtures treated with 0·3 and 0·6 per cent β-propiolactone were still lethal to mice, but when pooled were tolerated by rabbits, with, however, some œdema. The portion of filtrate treated with 0·6 per cent formalin was still highly toxic after 8 days incubation at 37° C. and was discarded. The portion treated with 3·0 per cent formalin became non-toxic after 3 days.

The antigenicity of all the samples was tested by the procedure already described, using three rabbits for each of the β-propiolactone-treated samples and two rabbits for the formalin-treated one. The antibody response of these rabbits is shown in Table 1.

Table 1. ANTIBODY RESPONSES TO β-TOXIN TOXOIDED WITH β-PROPIOLACTONE OR FORMALIN

Treatment of β-toxin preparations	Antibody contents of rabbit sera (β-antitoxin units/ml.)
0·3 and 0·6 per cent β-propiolactone (pooled samples)	100 60 170
0·9 per cent β-propiolactone	120 50 50
1·0 per cent β-propiolactone	80 80 110
3·0 per cent formalin	4 20
0·6 per cent formalin (12 different culture filtrates)	7·58 (mean value from sera of 90 rabbits. Range 22–3)

The reactions of β-toxin, before and after treatment with β-propiolactone, with a homologous horse antiserum in agar gel are shown in Fig. 1. The continuity of the band of precipitate formed between the antiserum and the various antigens in the peripheral wells shows that the reduction in toxicity obtained by treatment with β-propiolactone was not accompanied by any alteration in the reaction of the toxoid with antibody against the original toxin.

A similar experiment was undertaken with a purified preparation of β-toxin, a more stable protein antigen[3] prepared from filtrates of *Cl. welchii* Type *D*. The toxic and immunizing properties of β-propiolactone- and formalin-treated samples were examined together with their precipitation in agar gel and flocculation by the optimum proportions method. Here again, it was found that the toxicity was reduced much more rapidly by β-propiolactone than by formalin; that, in agar gel using the homologous horse antiserum, a common band of precipitate was given by the untreated samples and those treated with β-propiolactone at concentrations up to 1·2 per cent (Fig. 2). Samples treated with less than 0·9 per cent β-propiolactone had the same flocculation rates and optima as the untreated samples; higher concentrations of β-propiolactone led to a shift of the optimum towards higher antigen concentrations. In contrast to this, formalin treatment that was just sufficient to render our ε-antigen non-toxic produced a toxoid that no longer gave recognizable flocculation zones with antiserum and the reaction of which in agar gel was markedly altered, as was also shown by Schuchardt, Munoz and Verwey[4]. However, the antibody responses of rabbits inoculated with a β-propiolactone-treated ε-toxoid were only slightly better than those obtained with a similar formalin-treated preparation.

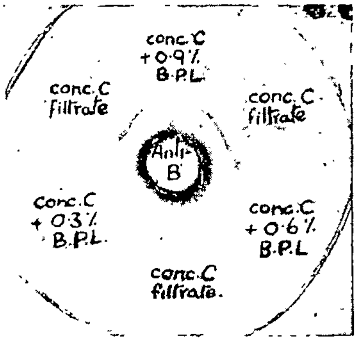

Fig. 1. Reactions of β-toxin (in a concentrated Type *C* filtrate) before and after treatment with β-propiolactone (*B.P.L.*), with Type *B* antiserum

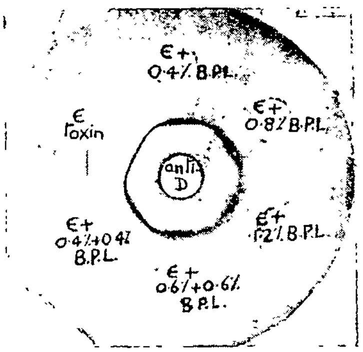

Fig. 2. Reactions of ε-toxin before and after treatment with β-propiolactone (*B.P.L.*), with Type *D* antiserum

The rapidity of the interaction of β-propiolactone with protein antigen makes it possible to avoid the prolonged incubation at 37° C. required by the formalin toxoiding process at the usual formalin concentrations, and any deterioration resulting from this. The apparent lack of change in the flocculating and agar gel precipitation behaviour of the β-propiolactone-treated toxoids indicates that β-propiolactone does not produce the changes in solubility and other side reactions (for example, cross-linking) which occur with formaldehyde. The experiments with ε-toxin, however, have shown that the preservation of these *in vitro* properties is not necessarily an index of better immunizing properties. This was also shown by Schuchardt *et al.*[4], who found that formalin-toxoided ε-preparations which no longer gave visible reactions with antitoxin still produced high antitoxin titres in sheep. The tenfold improvement in antibody response found when β-toxin is toxoided with β-propiolactone rather than formalin may be due to the inhibition of the breakdown process, probably enzymatic, which is responsible for the quick deterioration of β-toxin.

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ROLE OF HYALURONIDASE IN THE RE-ABSORPTION OF WATER IN RENAL TUBULES : THE MECHANISM OF ACTION OF THE ANTIDIURETIC HORMONE

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According to recent theories the antidiuretic hormone acts by increasing the permeability of the nephron walls. As a result, hypotonic urine, following the osmotic gradient, is reabsorbed[1-3]. That the neurohypophysial hormone dilates the minute membrane pores has been demonstrated for frog skin[4]. Diuresis and antidiuresis are presumed to be due to a similar change of pore size in the membranes of the distal tubules. Yet there is no direct evidence for this suggestion; it is based on indirect information, deduction and the analogy with the tests on frog skin.

A few years ago we discovered that under certain conditions the urine of all mammals contains hyaluronidase[5]. Hyaluronidase activity depends on the extent of diuresis, dropping to zero after water loading (Fig. 1).

A special analysis has shown that the reduction of activity during high diuresis cannot be accounted for simply by dilution of the enzyme entering the nephron lumen at a fixed concentration. The experiment in which increased urine formation is effected by osmotic diuretic loading, and not by water loading, is of particular significance. As is seen from Fig. 2, the increased urine flow during osmotic diuresis is not accompanied by decreasing hyaluronidase activity.

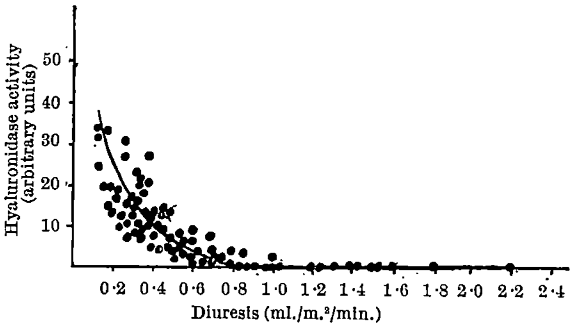

Fig. 1. Variation of diuresis with hyaluronidase activity

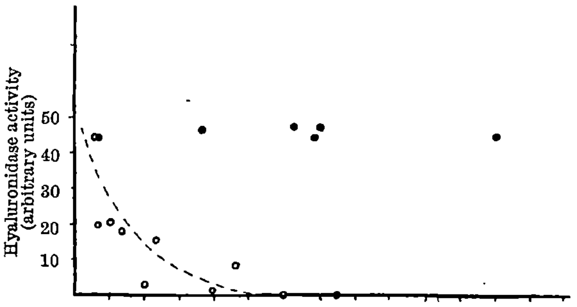

Fig. 2. ●, Osmotic diuresis; ○, water diuresis. According to experiments on the same dog

Hence we can infer that the amount of hyaluronidase in the nephron lumen is increased by neurohypophysial hormone: as the secretion of antidiuretic hormone is inhibited (water diuresis) the enzyme content in the urine drops, but it remains high when the hormone acts on the kidney (osmotic diuresis). This suggestion is supported by the following experiment.

Urea was administered to rats during complete water diuresis. As a result, urine formation increased. Pituitrin was then injected and diuresis decreased somewhat, but it remained high. Nevertheless, as is seen from Table 1, the urine acquired a considerable hyaluronidase activity[6].

Table 1

Water loading		Administration of urea		Injection of pituitrin	
diuresis (ml./mm.)	activity (arbitrary units)	diuresis (ml./mm.)	activity (arbitrary units)	diuresis (ml./mm.)	activity (arbitrary units)
1·2	0	2·5	0	1·9	11
1·5	0	5·5	0	2·2	13
1·8	0	7·0	0	1·1	11
2·8	0	6·0	0	5·5	28
2·8	0	6·0	0	2·8	31
4·5	0	6·0	0	2·8	30
4·5	0	11·0	0	2·8	16

These results led us to the conclusion that in the course of facultative re-absorption, osmotically free water leaves the lumen of the distal tubules not through the cell cytoplasm but through the intercellular cement, with hyaluronic acid as a constituent. In a state of hyperhydration of the organism, this cement is almost waterproof, which enables hypotonic urine to be formed.

During dehydration, antidiuretic hormone causes hyaluronidase secretion by the nephron cells. Under the action of the enzyme, mucopolysaccharides of the intercellular cement are depolymerized and undergo hydrolysis, the multicellular tubule membrane becoming permeable to water. By means of a direct histochemical study we have verified this suggestion[7].

White rats were used in our experiments. One group of animals was killed at the peak of water-diuresis, the other after being deprived of water for 48 hours or after pituitrin injection. The kidneys of hyperhydrated and dehydrated rats were quickly removed and studied histochemically.

On staining the kidney slices with toluidine blue, we found, in the area of the collecting ducts, structures

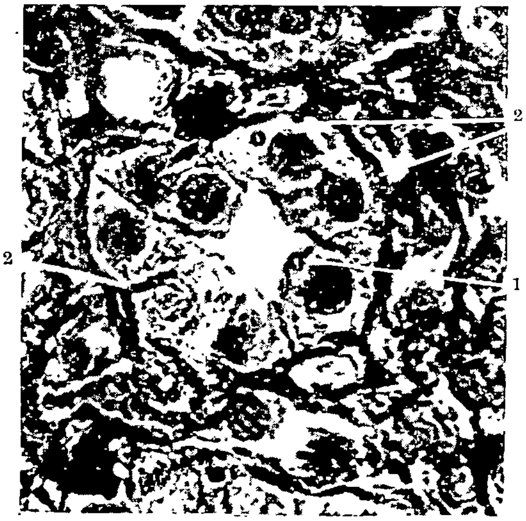

Fig. 3. The collecting duct region during water diuresis. 1, duct epithelium; 2, mucopolysaccharides in the intercellular cement and in the basement membrane; these are black on the microphotograph and stained red on the slice. (× 1,080)

showing the typical red metachromasia characteristic of hyaluronic acid. At the peak of water diuresis, the collecting duct epithelium consists of highly prismatic cells, with abundant cytoplasm and nuclei in the centre of cells (Fig. 3). Epithelial elements are cemented by intercellular layers stained red, which shows that they contain hyaluronic acid. On the photomicrograph they are seen as black lines. The basement membrane reveals a similar metachromasia which appears as clearly outlined fibres (red in the preparation and black in the photomicrograph) surrounding every duct.

This picture, typical of the kidney of a hydrated rat, changes abruptly when the animal undergoes dehydration or when pituitrin is administered (Fig. 4). The cells lose most of their cytoplasm and the nuclei project into the lumen. The reason for this change in the epithelium is the complete dissolution of the cytoplasmic apical ends into the lumen of the tubules. This loss of cytoplasm appears to be identical with apocrine secretion of the collecting duct epithelium due to antidiuretic hormone.

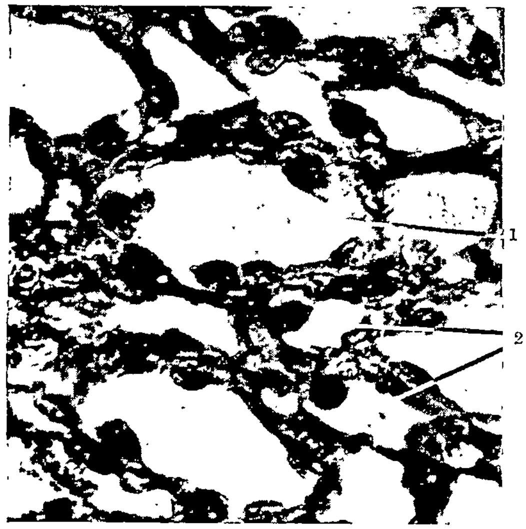

Fig. 4. The same region as Fig. 3 after pituitrin injection. The flattening of the duct epithelium is shown. Positive reaction to γ-metachromasia has given place to a diffuse pinkish background. 1, collecting ducts; 2, lymphatic capillaries. (× 1,080)

As a result of the antidiuretic hormone effect, the metachromasia of the fibres stained by toluidine blue changes, turning violet instead of red. When these changes reach their maximum, the mucopolysaccharide intercellular layers disappear completely and the hyaluronic elements of the basement membrane are no longer seen. γ-Metachromasia remains only as a diffuse homogeneous pinkish background uniformly filling in all the interstices between the ducts.

After injection of pituitrin, numerous tubules, previously unseen, appear in the meshes of the intertubular mucopolysaccharide net in the immediate vicinity of the ducts. In the cross-section of the walls of these new tubules, cells typical of the capillary endothelium are seen. There is much evidence that these tubules are lymphatic kidney capillaries which open under the influence of the antidiuretic hormone.

The processes which occur in the area of the collecting ducts as the result of natural antidiuresis brought about by continued lack of water are, in principle, similar to those that occur after injection of pituitrin.

The rapidity of morphodynamical change in the system of collecting ducts is startling: they reach a maximum 15–20 minutes after the injection of the hormone.

Water administered to dehydrated animals causes a quick reversal of all these changes. The first signs of the regeneration of hyaluronic stroma of the intercellular substance and epithelial elements appear in 20 minutes. Sixty minutes later, when intensive water diuresis sets in, the tubule structure approaches the state characteristic of the hydrated kidney. There is little doubt that the changes in kidney structure which are the morphological expression of antidiuretic hormone action underlie the antidiuretic action of the hormone.

We have arrived at the following conclusions based on these results.

1. Antidiuretic hormone stimulates the collecting duct cells, which begin to secrete apocrine-wise, hyaluronidase being a constituent of the secretion.

2. The secreted enzyme rapidly depolymerizes mucopolysaccharide complexes of the intercellular cement and the basement membrane of the tubules. This makes the structures separating the tubule lumen from the interstitial tissue permeable to water. The hypotonic fluid in the tubules then follows the osmotic gradient and undergoes facultative reabsorption.

3. The water entering the interstitial space is drained by an extensive system of newly opened lymphatic capillaries.

4. All these processes are localized in the most distal part of the nephron. It is the collecting ducts that are the main site of facultative water re-absorption. It seems reasonable to change the name 'collecting ducts' as it does not suggest the importance of the processes occurring inside the ducts.

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LETTERS TO THE EDITORS

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Radio Observations of Hypersonic Shock Waves

A SHOCK tube consists essentially of two sections, one containing a gas at high pressure and separated from the test gas in the other section by means of a diaphragm. A shock wave is produced in the test gas when the diaphragm is suddenly broken. As the initial pressure ratio is increased, the shock front attains a limiting velocity $U \approx \frac{\gamma_1 + 1}{\gamma_2 - 1} a_2$, and the corresponding limiting shock Mach number is U/a_1, where a_1, a_2 are the speeds of sound and γ_1, γ_2, the specific heat ratios (C_p/C_v) of the gases in the test and high-pressure sections respectively. Thus if both sections contained the same monatomic gas for which $\gamma = C_p/C_v = 1 \cdot 67$ the limiting shock Mach number would be approximately 4. Greater shock Mach numbers could be achieved if the speed of sound in the high-pressure section were increased, for example, by using a light gas and by raising its temperature. Thus hydrogen is a suitable driver gas, and it could also be brought to a high temperature by burning oxygen in it. An alternative method of producing a high shock velocity is to introduce an intermediate section into the shock tube[1]. When the first diaphragm is broken, a shock wave is produced in the intermediate section, and the resulting column of hot gas flowing at high speed in this section then acts as the final driver to initiate a faster shock wave in the test section. In a previous communication[2] we described the radio measurement of the velocity of shock waves by means of the Doppler effect. The value of this technique, which provides detailed measurement as the shock wave travels along the tube, is illustrated by its application to the study of methods for producing hypersonic flow.

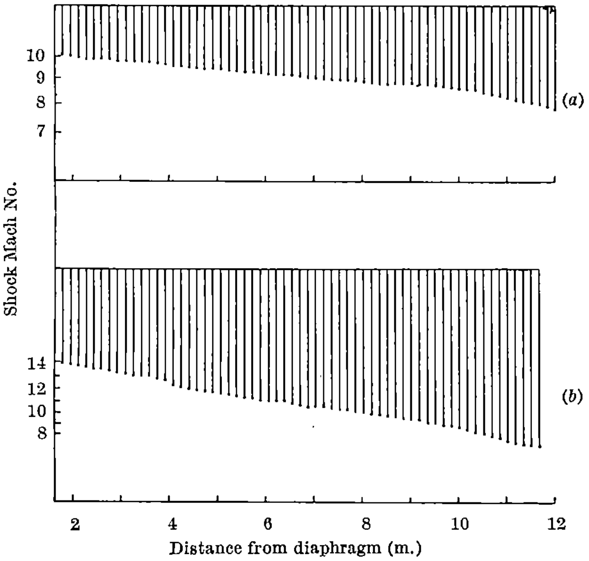

Fig. 1. Comparison of attenuation of shock waves in argon, initially at room temperature and 3·0 mm. pressure, using as driver: (*a*) hydrogen at room temperature and 32·7 atmospheres pressure; (*b*) a combustion mixture of hydrogen at 6·8 atmospheres pressure with 10 per cent oxygen

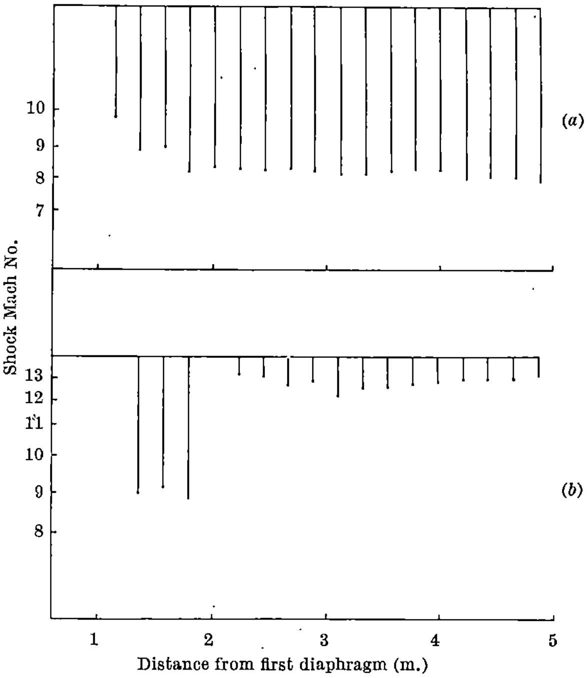

Fig. 2. Comparison of shock velocities using single and double diaphragms. The gases, initially at room temperature, and pressures as follow, are: (*a*) driver, hydrogen at 17·7 atmospheres; test section, argon at 5·0 mm.; (*b*) driver, hydrogen at 17·7 atmospheres; intermediate section, argon at 3·0 mm.; test section, air at 0·3 mm.

Attenuation is a most important consideration when a long shock tube is used to obtain a proportionately long column of flow at high Mach number. The attenuation is influenced not only by the diameter and surface construction of the walls of the tube, but also by lack of uniformity or turbulence in the action of the driver. Fig. 1 shows for comparison the shock velocities obtained in argon in a steel shock tube of internal section 5·4 cm. square using an aluminium diaphragm when the gas in the high-pressure section is (*a*) hydrogen at room temperature and (*b*) a combustion mixture of hydrogen with 10 per cent oxygen. With the cool hydrogen as driver, the shock velocity which initially corresponded to a Mach number of 10 (relative to the argon in its initial state at room temperature) fell to about Mach 8 in a distance of 10 m. When heated by combustion, the driver produced a higher initial velocity, equivalent to nearly Mach 14, but in a distance of 10 m. the Mach number had fallen to about 7. This greater attenuation is attributable to the imperfect state of the combustion mixture. Although it may be possible to improve the combustion technique, the serious attenuation shown in Fig. 1*b* occurred when a heated wire was held lengthwise down the high-pressure section to attain uniformity in the combustion process. Previous trials of multiple ignition points had proved far less satisfactory.

The experiments on the alternative method using an intermediate section were performed in a shock tube made of silver-plated brass having a circular section of internal diameter 5·1 cm. Typical results obtained in this tube with a single diaphragm of aluminium, again using hydrogen at room temperature as driver, are shown in Fig. 2*a*. Excluding the initial stages during shock formation, the velocity of the shock wave decreased only slightly during its transit along the 5-m. distance from the diaphragm to the end of the tube; the attenuation is of the same order as that shown in Fig. 1*a*, which corresponds to about 0·2 in Mach number per metre. A second diaphragm was then introduced in order to form an intermediate section. The second diaphragm is relatively weak, as it is required only to withstand the comparatively low pressure in the intermediate section and to break when the intermediate shock wave impinges on it. A suitable material is 'Melinex', a polyester film manufactured by Imperial Chemical Industries Ltd., which also has the advantage of transparency to the 6-cm. radio waves used for the Doppler system of velocity measurement. The radio probe could thus look through the second diaphragm to observe the oncoming shock in the intermediate section as well as the shock produced in the final section. Fig. 2*b* shows the results obtained using hydrogen in the high-pressure section, and argon and air in the intermediate and final sections respectively, all the gases being initially at room temperature. With the pressure ratios noted on the diagram, a Mach number of 9 was obtained in the intermediate section jumping to Mach 12 in the final section and showing no evident attenuation. These results indicate that the double-diaphragm method appears to be much more promising than the combustion method for attaining high shock velocites in the shock tube without undue attenuation.

We are indebted to M. Woolley for his help in adapting the Doppler technique to the circular-section tube.

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Mode of Growth of Ice Crystals in Air and other Gases

It is widely known that the habit of ice crystals grown in air depends markedly on the temperature and excess of water vapour. This dependence was first studied by Nakaya and his collaborators and their results have been confirmed by many other investigators, but the problem of the factors determining habit remains unsolved.

The change of the ice crystal habit at water saturation vapour pressure with temperature is as follows: between 0° C. and about −3° C. ice crystals grow to thin hexagonal plates without internal design; between about −5° C. and −9° C. hexagonal prisms or columns are formed, between −10° C. and −20° C. hexagonal plates are again formed but thicker than at the higher temperature-range and with intricate design, with the frequent occurrence also of stellar forms and dendrites; and below −20° C. ice crystals grow along their principal axes in complex prismatic shapes. Marshall and Langleben[1] stated that the dependence of ice-crystal habit on temperature and supersaturation can be explained in terms of water-vapour excess over ice-saturation, whereas the experiments of Shaw and Mason[2] showed that the crystal habit is determined primarily by temperature, while the degree of supersaturation only modifies it. Kobayashi[3] came to the same conclusion as a result of experiments similar to those made by Nakaya *et al.* I have suggested[4] that the rate of diffusion of water vapour in air and the thermal conductivity of air play important parts in determining the mode of growth, and consequently that ice crystals should grow in different modes in air at a low pressure and in gases into which water vapour diffuses at different rates.

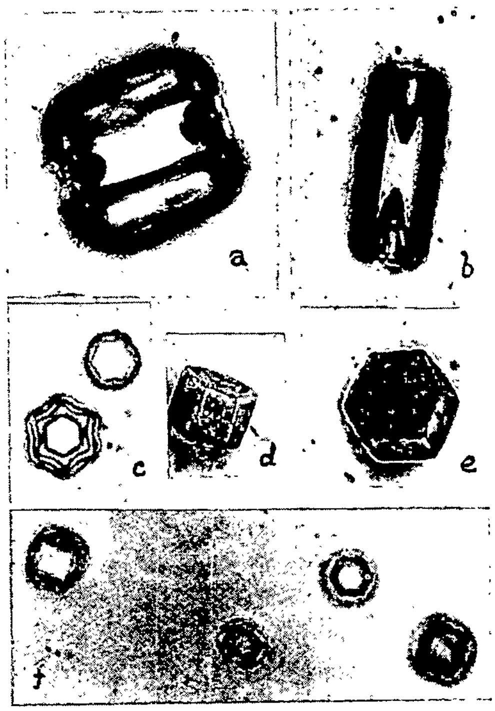

Fig. 1. Ice crystals grown in gases saturated with water vapour (×700). (*a*) Hydrogen at −7° C., (*b*) carbon dioxide at −7° C., (*c*) air at normal pressure at −16° C., (*d*) and (*e*) air at low pressure (40 mm. mercury) and at −16° C., (*f*) hydrogen at −16° C.

Experiments were therefore carried out on the growth of ice crystals in air at a low pressure and in various gases at temperatures of about −7° C. and −16° C. at water saturation; as is well known, between these temperatures a marked change in the growth habit of ice crystals is observed in air at normal pressure, since ice crystals grow preferentially along their principal axes in columnar form at −7° C. and along their lateral axes in plate-like or stellar forms at −16° C.; skeletal structures develop at both temperatures in air.

My experiments involved seeding a supercooled water cloud with silver iodide smoke in a cold chamber. In an atmosphere of hydrogen at normal pressure and in air at low pressures (80–20 mm. mercury) ice crystals grew in similar modes at −7° C. and at −16° C. which were very different from those in which they grew in air at normal pressure; in the former cases they grew to short and thick columns and skeletal structures did not develop in them. This tendency was more easily observed in air at low pressure than in hydrogen (Fig. 1). The diffusion coefficients of water vapour in hydrogen and in air at the low pressures employed are respectively 3·4 times and 10 or more times as large as that in air at normal pressure. Experiments on ice crystals grown on rabbit hairs suspended in the cold chamber yielded similar results: the ice crystals grew at nearly equal rates along the principal and lateral axes at temperatures between −7° C. and −16° C.

In carbon dioxide (in which the diffusion coefficient of water vapour is 60 per cent of that in air at normal pressure) the growth habit of ice crystals was nearly the same as in air at normal pressure, but the change in habit with temperature and the development of skeletal structures were more pronounced than in the latter case.

No difference in growth habit was observed between ice crystals grown in oxygen, nitrogen and air at normal pressure. The fact that ice crystals grow in nearly the same mode in hydrogen and in air at low pressure, excludes the possibility that the difference in thermal conductivity at normal pressure between hydrogen and air might give rise to the difference in habit, for the thermal conductivity of hydrogen is much greater than that of air at low pressure (80–20 mm. mercury) which, in turn, is not markedly different from that of air at normal pressure. The results obtained with the gases mentioned above show that molecular adsorption of a particular gas, hydrogen or oxygen or nitrogen, is not responsible for the particular mode of growth in that gas. The characteristic mode of growth of ice-crystal in hydrogen at normal pressure and in air at low pressure may be considered to be due to the high rate of diffusion of water vapour through the gases.

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The High-Energy Proton Beam as a Neurosurgical Tool

Irradiation with high-energy heavy particles is suitable for the destruction of small selected regions in the central nervous system. Tobias *et al.*[1] irradiated the hypophysis of animals and man with 190-MeV. deuterons and 340-MeV. protons. Anderson *et al.*[2] made lesions in the hypothalamus of the rat using 190-MeV. deuterons. Malis *et al.*[3], making use of the thin ionization peak at the end of the beam, produced lesions at a depth of 0·8 mm. in the cerebral cortex of the cat with 10-MeV. protons. The continuation of animal experiments and the possible application of heavy-particle beams to stereotaxic radiosurgery in man[4,5] make it essential to know their effects on the central nervous system in detail.

A summary of work of the past two years is given, showing that with high-energy protons a sharply delimited lesion can be made at any desired site in the central nervous system. In the experiments some 50 rabbits and 5 goats were used. Only lesions observed up to 2 months after irradiation are considered here.

Irradiation was performed by a 185-MeV. proton beam from the 230-cm. synchrocyclotron. By focusing magnets and sweeping coils an almost parallel beam with a uniform cross-section of variable size was obtained. The desired beam profile was determined by a final aperture. The mean dose-rate was 1,000–2,000 rad per min. Dose distributions were calculated from density measurements on photographic films exposed in a water phantom and calibrated in terms of relative dose.

Transection of the spinal cord. Beams 1·5 and 10 mm. broad were directed across the spinal cord of rabbits. Lesions appeared following doses of 40,000 and 20,000 rad on the third and ninth day respectively. The lesion was sharply defined and in the white matter had the same width as the beam; it was slightly narrower in the grey matter. The changes after irradiation with the 1·5-mm. beam consisted of necrosis of nerve cells, axons, myelin sheaths and glial cells. Small perivenous hæmorrhages were present at the margin of the lesions and occasionally in the centre. A week after the onset of paresis, gitter cells and some glial cells containing iron were seen at the edge of the necrosis, and within 2–3 weeks large numbers of gitter cells were observed in sharply demarcated cystic spaces in the white matter. Slight proliferation of astrocytes occurred around the lesion. Using a 10-mm. beam the tissue reactions were more severe. There were multiple and sometimes rather large hæmorrhages as early as 3 days after irradiation. The results are reported by Larsson *et al.*[6].

Transverse lesion of the cerebral hemispheres. A beam 1·5 mm. broad was directed transversely through the upper part of the frontal lobes of rabbits. The dose was 20,000 rad. The rabbits remained in good condition and were functionally unaffected. The earliest lesions observed, 14 days after irradiation, and the changes between 2 and 8 weeks were similar. Corresponding to the path of the beam, a groove 2 mm. wide appeared on the upper surface of the hemispheres, and beneath it, in both the grey and white matter, a sharply defined narrow band of discoloration was seen. Within the lesion (Fig. 1) necrosis of nerve cells, myelin sheaths and axons occurred. Minute hæmorrhages were present in the damaged tissue, particularly in the grey matter. Collections of gitter cells were seen in the necrotic zone and around it proliferation of astrocytes.

Restricted lesion in the depth of the brain. Lesions were produced in the internal capsule of the goat

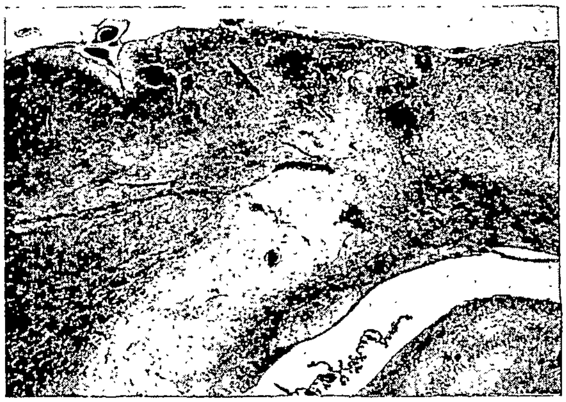

Fig. 1. Lesion of a rabbit's brain 2 weeks after irradiation with a proton beam 1·5 mm. broad. Dose, 20,000 rad. Small hæmorrhages occur in the damaged tissue, particularly in the grey matter. Azan. (× 8)

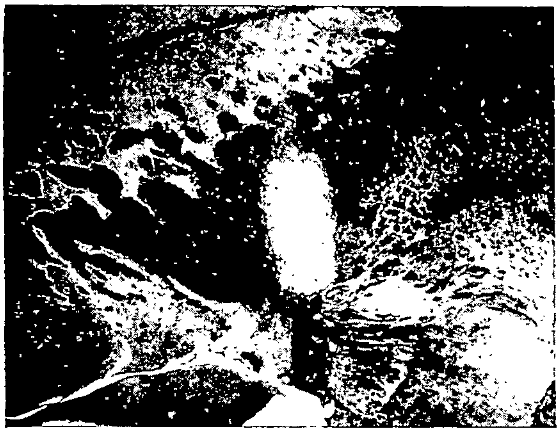

Fig. 2. Lesion in the internal capsule of a goat's brain 7 weeks after multiple port irradiation with a proton beam 2 mm. × 7 mm. Dose, 20,000 rad. Note the sharp demarcation of the lesion. Gros-Thionin. (× 4)

by the stereotaxic method[7], using multiple-port irradiation. A beam 2 mm. × 7 mm. or 2 mm. × 10 mm. and 20–22 fields were used, giving a dose of 20,000 rad at the desired site. The animals remained in good condition. Examined 4 and 7 weeks after irradiation, they presented restricted lesions in the selected areas (Fig. 2). The damaged region was lentiform and about 3 mm. × 7–10 mm. × 13–16 mm. The myelin sheaths, axons and glial cells within the lesion were completely destroyed. Slight cellular reaction was seen around some vessels at the periphery of the lesion. No hæmorrhages were seen in or around the necrotic zone, and there was no marked proliferation of astrocytes in the neighbourhood of the destroyed tissue.

With a narrow proton beam it is therefore possible to produce sharply delimited lesions of a desired site in any region of choice in the central nervous system. It must be stressed, however, that the observations apply only to lesions in their relatively early stages. The method is convenient for animal experiments.

To what extent such procedures may be used in operations on man depends on the late changes following high doses of proton radiation. Work in progress will demonstrate the long-term effects of such irradiation on the brain.

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A New Approach to the Investigation of the Cause of Moisture Expansion of Ceramic Bodies

ALTHOUGH moisture expansion of ceramic bodies has been studied by many investigators its cause is still not known with certainty. The hydratable materials that play a part may be anhydrous clay minerals[1,2], γ-alumina[3], amorphous silica (silica gel)[4,5], alumino-silicic acid gel[5] and permutites, zeolites or glass[1–3,6,7]. These are all amorphous (or poorly crystalline) materials that might be expected to appear at some stage in the firing of a clay body. In the past, studies on natural materials have been complicated by complex mineralogy and/or the presence of impurities, and it has been difficult to assess the influence of each component on moisture expansion. To overcome this we have studied moisture expansion using pure co-precipitated and mixed gels of silica and alumina and some to which an impurity of sodium oxide has been added. The work forms part of an investigation into the nature and cause of the permanent moisture expansion of ceramic bodies being carried out in this Division.

The moisture expansions produced by autoclaving fired test pieces of co-precipitated gels in saturated steam at 200° C. until expansion ceased are illustrated in Fig. 1. On firing to low temperatures pure alumina gel has a high moisture expansion due to the rehydration of γ-alumina to boehmite. At high temperatures of firing the alumina gel is transformed into α-alumina, which is moisture stable. Pure silica gel shows a moisture expansion at all temperatures of firing, but this drops as cristobalite forms. All moisture expansion curves show minima at the composition of mullite, but for low temperatures of firing the formation of mullite is not complete and an appreciable moisture expansion results from the presence of unreacted alumina and silica gels. Between the composition of mullite and pure silica gel the moisture expansion curves pass through maxima which are near the composition of kaolinite and which fall as the

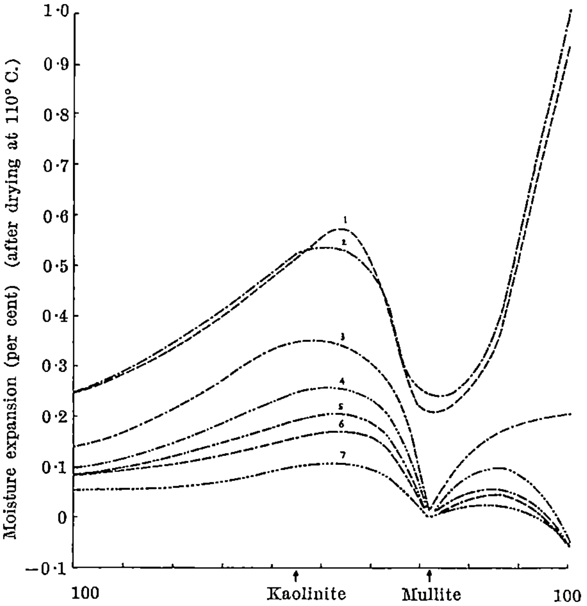

Fig. 1. Moisture expansion of co-precipitated gels of silica and alumina fired at temperatures: (1) 850°; (2) 900°; (3) 950°; (4) 1,000°; (5) 1,050°; (6) 1,100°; (7) 1,200° C.

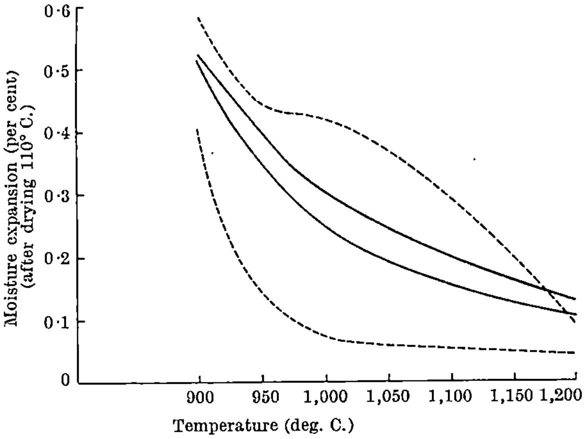

Fig. 2. Moisture expansion of pure and impure (addition of 2 per cent sodium oxide) gels with silica/alumina ratios of 2 formed by (1) co-precipitation and (2) mixing of the two components and fired at temperatures between 900–1,200° C. Top to bottom: mixed gel and sodium oxide; co-precipitated gel and sodium oxide; co-precipitated gel; mixed gel

firing temperature is increased. The only crystalline phase in this region is mullite, but there is much amorphous matter present which may be likened to Holdridge's alumino-silicic acid gel[5]. Between the composition of mullite and pure alumina gel the moisture expansion curves show a second series of maxima. These are considered to be due to the rehydration of γ-alumina to boehmite since the presence of silica prevents the formation of α-alumina even at a firing temperature of 1,200° C.

Particularly significant results are obtained by studying the moisture expansion after firing of pure and impure (addition of 2 per cent sodium oxide) gels with silica/alumina ratios of 2 (the composition of kaolinite) formed (1) by co-precipitation, (2) by mixing wet precipitated gels of the two components. The moisture expansion curves for the co-precipitated gels (Fig. 2) show that the addition of the alkali has only a slight effect, whereas in the cases of the mixed gel it has a pronounced effect and produces a curve resembling that for natural kaolinites[1,2]. This indicates that under conditions of incomplete mullitization, which exist in the mixed gels, the residual silica and alumina have reacted with soda to form a sodium alumino-silicate with swelling properties, as has been suggested for fired kaolinites[1-3,6]. However, it is doubtful if this material should be termed permutite or zeolite, since there are indications from fired kaolinites[2,3] that it possesses a low exchange capacity.

X-ray examination provides further important data on the sodium alumino-silicate. The samples of the mixed gel contain amorphous matter, γ-alumina and mullite at low firing temperatures, but at about 1,000° C. γ-alumina passes into α-alumina and at about 1,150° C. amorphous matter passes into cristobalite. Any change in structure induced by autoclaving is not revealed by X-ray examination. However, in the mixed gel with soda the cristobalite has an expanded lattice (of the order of 4 per cent volume increase) compared with that formed from the soda-free mixed gel and from pure amorphous silica.

The expanded cristobalite is probably to be considered as the β-form, metastable at room temperature, since it showed no inversion when heated. Cristobalite with similar properties has been found in opal[8] and Fuller's earth[9]. Buerger[10] suggested that the failure of the β-form to invert on cooling may be due to very small crystal size, whereas Flörke[9] considered it due to the existence of disordered forms arising from irregular stacking sequences of Si-O tetrahedral layers. We consider that it is due to the substitution of some Al^{3+} for Si^{4+} in the tetrahedral framework with the balance of charge maintained by Na^{+} held in cavities of the structure. On this hypothesis, and because the moisture expansion drops as cristobalite crystallizes, it is reasonable to conclude that the precursor to the cristobalite is an amorphous sodium alumino-silicate produced from amorphous silica, γ-alumina and sodium oxide on firing at about 1,000° C. It thus seems correct to ascribe to this amorphous compound the rise in moisture expansion in the region 1,000–1,150° C. for the mixed gel to which soda was added, for kaolinite[1,2] and, within limits, for kaolinite to which additions have been made[2,3].

Moisture expansion of low-burnt ceramic bodies can be due to the rehydration of anhydrous clay minerals[1] and that of high-burnt bodies to the rehydration of glass[7]. Our results demonstrate that amorphous alumino-silicates, amorphous silica and γ-alumina can also play important parts, depending upon the composition of the body and the firing temperature.

A fuller account of these results is to be published elsewhere.

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Effect of Temperature on the Structure of Set Gypsum Plaster

VARIATIONS within the normal range of temperature do not exert a very profound effect upon the rate of hydration of gypsum plaster[1,2]. For example, Fig. 1 shows the maximum rate of increase of temperature and the induction period (defined as the time required for the rate of increase of temperature to reach 0·1° C. per min.) plotted against initial temperature for a commercial plaster consisting predominantly of the so-called hemi-hydrate of calcium sulphate. The plaster had been allowed to age until it gave steady results. The reactions were carried out in a Dewar flask so that the increase in temperature is a valid parameter of the reaction. It is seen that the induction period is constant from 0° to 40° C., above which temperature it increases gradually. The maximum rate reaches a feeble maximum at about

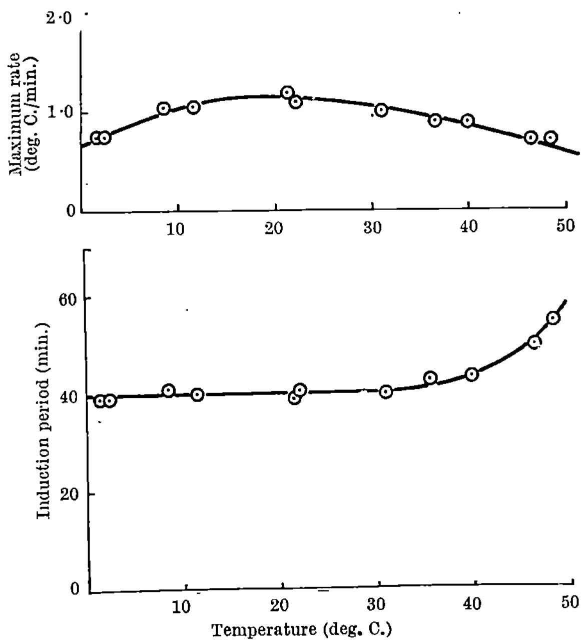

Fig. 1. The maximum rate of increase of temperature and the induction period plotted against initial temperature for a mixture of 100 gm. plaster in 60 ml. water

25° C. It appears, however, that at higher temperatures the rate of hydration does drop considerably[3]. Results similar to those shown in Fig. 1 were obtained for another plaster from a different source.

I have developed a method for examining the structure of set plaster under the microscope[4], and Fig. 2 shows the structures developed by a mixture of 100 gm. of plaster in 60 ml. water when setting took place at 0°, 20° and 46° C. The plaster belonged to the batch the kinetic characteristics of which are shown in Fig. 1, and it is seen that, despite the comparatively feeble effect on the rate of the setting process, temperature exerts a profound effect on the structure after setting has taken place. The differences are so great that the material produced at one temperature cannot be recognized from its appearance when prepared at another temperature. At 46° C. a sheaf-like habit predominates, whereas at 20° C. swallow-tail twins and an acicular habit are the rule. At 0° C., a fine structure which could not be fully resolved was obtained. Examination by X-rays showed that in no case was any material other than well-crystallized gypsum present in detectable quantities. The grain sizes of the specimens cast at the three different temperatures (Fig. 2) show that not only does the habit of the gypsum change as the temperature is raised but also that the number of effective nuclei decreases. It is also evident that the average pore size becomes much larger. Similar results were obtained for six commercial plasters representing gypsum deposits in four States of the Commonwealth of Australia.

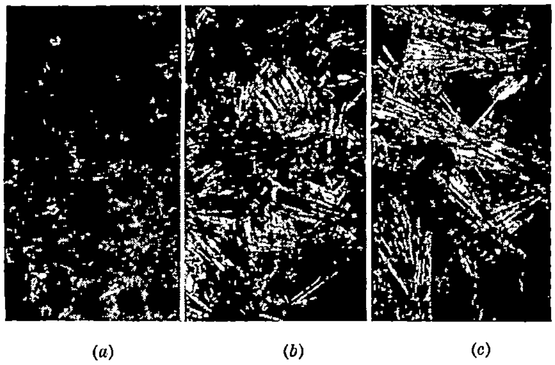
(a) (b) (c)

Fig. 2. The structure developed in a mixture of 100 gm. of plaster in 60 ml. water set at various temperatures: (a) 0°; (b) 20°; (c) 46° C.

The extreme members of the series shown in Fig. 2 refer to conditions outside the range of experience in the plaster industry. However, further work has revealed that the type of structure shown in Fig. 2*a* may extend to about 10° C. or even higher, and that the high-temperature type is dominant at 30° C. In fact, a considerable variation of structure is possible over the range of practical working temperatures.

It is expected that changes in structure will be associated with changes in other properties. Preliminary experiments confirm that the breaking strength is appreciably affected. For example, specimens cast at 0° C. are about 12 per cent stronger[1,5] than those cast at 29° C. Work carried out in this Division indicates that structural changes of this type may be associated with changes in the adhesion of paint films (Hoffmann and Ridge, unpublished results) and in the expansion on setting.

It is suggested that the properties of plaster after setting may be more dependent upon temperature than was previously thought, and that some of the sporadic problems of the plaster industries, such as the 'crazing' of fibrous plaster sheets, may be associated with unusual conditions of temperature at the time of casting.

This investigation forms part of the programme of work carried out within the Division of Building Research and sponsored by the Associated Fibrous Plaster Manufacturers of Australia.

Thanks are due to Dr. W. F. Cole for the X-ray diffraction patterns.

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A New Method for obtaining Thin Plane Parallel Sections of Mineralized Specimens

Nowadays a number of micro-methods (for example, X-ray and interference microscopy, and isotope techniques) are used for quantitative analyses of mineralized biological tissues. These methods have a resolution which allows analyses at or below the cellular scale. Difficulties in preparing the biological material have so far been a limiting factor in the application of the methods. An ideal specimen is a thin, plane parallel tissue section with a known thickness within the region 10–100μ. In order to prepare such sections, blocks are generally ground down to a desirable thickness, but all such methods so far used possess serious disadvantages: they do not allow a continuous control of the thickness during the grinding procedure, and wedge-shaped sections or fragments of sections are often obtained. These difficulties prompted us to seek a method for preparing ground sections based on lapping technique.

Mineralized tissue embedded in methyl methacrylate is used. The specimens are sawn into sections 3–4 mm. thick. One side of the section is lapped against cast-iron using very fine diamond abrasive, which gives the surface an extremely good quality with regard to both planarity and surface finish.

For the subsequent steps of the lapping procedure a small steel cylinder is used as a fixture for the specimen. A square-ruled area is etched on one of the plane surfaces of the cylinder, which are perpendicular to its axis. The etched lines are a few microns deep and have a width of about 50μ. On top of the etched area the lapped surface of the specimen is attached with the aid of a glue which is easy to work out to a thin film less than 0·5μ thick. When the glue is dry the specimen is cooled and ground by hand against an ordinary emery plate, down to about 1 mm. thickness.

The next step comprises grinding against a fine-grained diamond plate. The fixture is moved by hand in a V-shaped prism which is oriented perpendicularly to the rotating plane of the grinding plate. At this stage, a section of about 100μ is obtained within a few minutes. The shape of the fixture allows continuous approximate measurements of the specimen with the aid of an ordinary micrometer.

In the last step the specimen is lapped against a cast-iron plate using fine-grained diamond abrasive, the fixture being oriented with its longitudinal axis perpendicular to the lapping plane. The sections are lapped by hand to the desired thickness, checked by repeated measurements. A coarse control of the thickness of about ± 2μ can be obtained with the aid of a good micrometer. A more accurate control of thickness can be achieved with the aid of a 'microkator' (a Swedish mechanical measuring instrument, manufactured by C. E. Johansson). A complete topographical thickness-measurement, with the same lateral resolution as the light microscope can be obtained with the aid of a mechanical-optical instrument designed by Hallén[1].

Good sections have been obtained with our prototype equipment. For example, thickness measurements of a cross-section 17μ thick of the crown of a tooth was made. The thickness was measured at 100 arbitrarily distributed points within the dentin as well as the enamel. The mean thickness was 16·7μ, standard error 1·7, which gives a coefficient of variation of 10·3 per cent. The section is slightly wedge-shaped with a slope of 1/5,000.

A more detailed report will be published elsewhere.

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Aug. 27.

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Anodic Reactions of Mercury with Halide Ions in Dimethylformamide

DIMETHYLFORMAMIDE and other organic solvents are being increasingly used for the polarography of organic substances and inorganic ions. It has been shown that a mercury pool anode in halide solutions in dimethylformamide provides a stable reference potential[1] and that this potential (and that of similar electrodes in other organic solvents[2]) differs considerably (by about − 0·5 V.) from that of the aqueous calomel electrode[1]. We have therefore studied the behaviour of iodide and chloride ion at the dropping mercury electrode in dimethylformamide in order to identify the anode reaction and ascertain why it maintains the pool at a stable potential. The results make it clear that some familiar aspects of the solution chemistry of mercury are changed when dimethylformamide is used as solvent.

We find that tetraethylammonium iodide in 0·1 *M* lithium perchlorate in dimethylformamide gives two reversible anodic waves ($E_{1/2}$ − 0·32 and + 0·10 at 20° C. at 1·96 m*M* concentration versus saturated calomel electrode; $i_d/cm^{2/3}t^{1/6}$, 1·24 and 0·50). Progressive addition of mercuric perchlorate made first one and then the other wave cathodic, with no significant change of other characteristics. Following the methods used by Kolthoff and Miller[3] in their study of mercury complexes in water we assumed the electrode reaction of the more negative wave to be:

$$\mathrm{Hg} + a\mathrm{X}' \rightleftharpoons \mathrm{HgX}^{(a-2)-} + 2\varepsilon \qquad (1)$$

for which the potential of the dropping electrode would be given by:

$$E_{de} = \text{const.} + \frac{RT}{2F} \ln \frac{i}{(i_d - i)^a} \qquad (2)$$

We plotted E_{de} for the more negative wave against the logarithmic function of equation (2) for various values of the exponent a. If one takes $a = 4$ a good straight line of slope 0·029 (= $2{\cdot}303RT/2F$) results; the electrode reaction is therefore:

$$\mathrm{Hg} + 4\mathrm{I}' \rightleftharpoons \mathrm{HgI}'' + 2\varepsilon \qquad (3)$$

When 0·1 *N* tetraethylammonium iodide is used as the supporting electrolyte in polarography in dimethylformamide the galvanometer zero is at − 0·55 V. versus standard calomel electrode; hence one is limited to the study of substances of half-wave potential more negative than this, since at less-negative potentials the mercury micro-electrode dissolves, according to equation (3). Similarly, when a diffusion current passes through the cell owing to reduction of a substance in the solution, the same reaction must occur on the mercury pool if this is used as anode. We suggest that the stability of the pool potential is to be accounted for by supposing that complex formation maintains a concentration of mercury ions in solution sufficiently high to ensure that further quantities, produced by electrolysis, do not increase the total concentration by a significant fraction. It should be borne in mind that the overall stability constant of the complex ion is high[4], and that there is a large and constant excess of iodide ions (the stability constants of the halide complexes in dimethylformamide, which we have estimated from polarographic data, will be reported elsewhere).

We do not discuss here the nature of the more positive wave given by iodide ion, because it is not relevant to the behaviour of the anode in polarography in iodide as supporting electrolyte.

The chloride ion (as lithium chloride) behaves similarly to iodide ($E_{1/2}$, $-0{\cdot}17$ and $+0{\cdot}125$ V. versus standard calomel electrode in 4·97 m*M* solution; $i_d/cm^{2/3}t^{1/6}$, 1·16, 0·53). Here, however, there is evidence that as well as $HgCl_4''$ another complex of mercury, with a lower ratio of halogen to metal, is formed to some extent. We have also observed that in dimethylformamide the precipitation of calomel on addition of mercury to a solution of mercuric chloride:

$$Hg + HgCl_2 = Hg_2Cl_2$$

is prevented by the presence of chloride ion (in water, precipitation does occur even if chloride is present). Moreover, calomel slowly dissolves in a dimethylformamide solution of lithium chloride (but not if the chloride is absent). It is clear, therefore, that a mercury pool in chloride solution cannot be in effect a calomel electrode as it is in aqueous chloride solutions. In fact we have found[1] that a 'calomel electrode' made up in dimethylformamide with 2 *N* lithium chloride has initially a potential close to that of the saturated aqueous calomel electrode, but the potential is not stable, owing no doubt to the slow dissolution of the calomel.

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A Theoretical Expression for Solubility Product

In view of the great importance of the 'solubility product' in chemistry, it was considered desirable to obtain a theoretical expression, to explain the observations described in a previous communication[1] and also to correlate the solubility product with some significant properties of the ions which combine to form the precipitates.

When two dilute aqueous solutions of electrolytes (for example, barium chloride and potassium sulphate) are mixed, the oppositely charged ions (Ba^{2+} and SO_4^{2-}) are brought into close association owing to electrical attraction and combine to form molecules of the precipitate (barium sulphate). The attraction is caused partly by Coulomb forces and partly by the mutual polarization of ions (ion–dipole interactions). The potential energy of a system consisting of oppositely charged ions is thus:

$$U = \left\{ -\frac{(z_+\varepsilon).(z_-\varepsilon)}{R_0}\left(1 - \frac{1}{n}\right) - \frac{\alpha_a(z_+\varepsilon)^2 + \alpha_c(z_-\varepsilon)^2}{2R_0^4} \right\} \quad (1)$$

where z_+ and z_- are valencies of the cation and anion, ε is the electronic charge, α_c and α_a are polarizabilities of the positive and negative ions, R_0 the equilibrium distance between the centres of the two ions, and n, a constant (about 9) occurring in Born's repulsion-energy term.

Redispersion of these ions from the precipitate does not take place unless they possess energies exceeding E (equal to $-U$). The stronger the binding forces between the ions, the smaller is their tendency to pass out into solution as free ions, and hence the greater the insolubility of the precipitate formed.

The velocity of recombination of the oppositely charged ions in solution, which is an instantaneous process (for which the energy of activation is practically zero), is:

$$k_1.(n_{Ba^{2+}}\ n_{SO_4^{2-}}) \quad (2)$$

where $n_{Ba^{2+}}$ and $n_{SO_4^{2-}}$ are the numbers of these ions per unit volume (concentrations) and k_1 is a constant.

The velocity of the reverse process, namely, the redispersal of ions from the surface of the precipitate into solution, is:

$$k_2.A.n_0 \exp(-E/RT) \quad (3)$$

where A is area of the interface of the particles of the precipitate and n_0 is the number of pairs of ions (Ba^{2+} and SO_4^{2-}) per unit area of the surface. At equilibrium:

$$k_1.(n_{Ba^{2+}}\ n_{SO_4^{2-}}) = k_2.A.n_0.\exp(-E/RT) \quad (4)$$

But by definition $(n_{Ba^{2+}}\ n_{SO_4^{2-}}) = S_P$, the solubility product of barium sulphate. Introducing the value of E given in (1) we have:

$$S_P.\left(\frac{k_1}{k_2An_0}\right) = \exp(-E/RT) = \exp\left[-\left\{\frac{z_+z_-\varepsilon^2}{R_0}\left(I - {}_{n}\right) + \frac{\alpha_a z_+^2\varepsilon^2 + \alpha_c z_-^2\varepsilon^2}{2R_0^4}\right\}\Big/RT\right] \quad (5)$$

S_P is a constant at constant temperature if A is constant. Thus,

$$-\log_e S_P = \frac{E}{RT} + a = \left\{\frac{\alpha_a z_+^2\varepsilon^2 + \alpha_c z_-^2\varepsilon^2}{2R_0^4}\right\}\Big/RT + a \quad (6)$$

since for very small values of R_0 the first term in (1), namely $\left(\frac{z_+z_-\varepsilon^2}{R_0}\right)$, can be neglected in comparison with the second term representing the mutual ion-dipole interactions. If temperature is constant, expression (6) reduces to:

$$-\log_{10} S_P = K(\alpha_a z_+^2 + \alpha_c z_-^2) + a \quad (7)$$

(K_1 and a are constants. For compounds of similar chemical constitution R_0 is nearly constant.) We should therefore expect to obtain a straight line by plotting $-\log_{10}S_P$ against $(\alpha_a z_+^2 + \alpha_c z_-^2)$. This is in agreement with results represented graphically in Fig. 1, obtained from known values of S_P and the polarizabilities of the constituent ions.

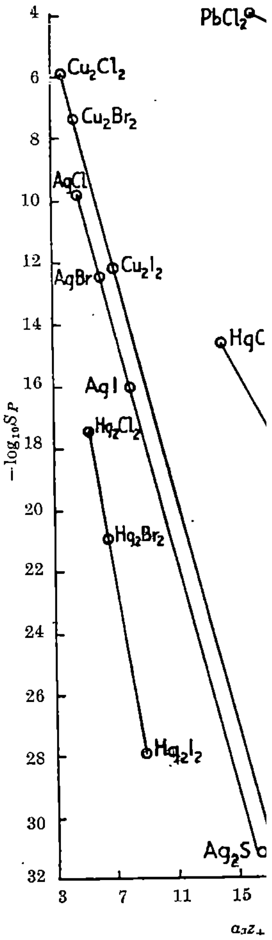
It is known that $\alpha = r^3$ for a spherical molecule, assumed to be a perfect conductor. Applying this to ions, we have:

$$-\log_{10} S_P = K_1\left\{\frac{r_a^3 z_+^2 + r_c^3 z_-^2}{2R_0^4}\right\}\Big/RT + a \quad (8)$$

If we now compare salts which are chemically similar, having one common ion and the other ion having the same valency (T being constant), equation (7) becomes:

$$-\log_{10} S_P = K_1'\alpha + a = K_1'r^3 + a' \quad (9)$$

This explains our previous observation[1] that the most insoluble inorganic precipitates are formed from hydrated ions having the largest size (including the hydration layer). On plotting $-\log_{10}S_P$ against $1/d^3$, where d is the distance of the diffusion front of each band from the starting point of diffusion, when we examine the bands in a chromatogram produced in an agar-gel layer containing the appropriate reagents during the diffusion of the electrolytes, then



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Equation (9) is consist
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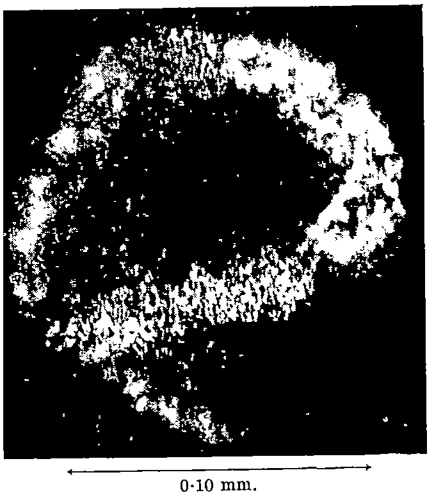
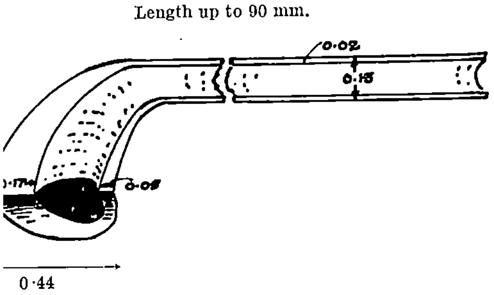


Fig. 1. Cross-section of whisker

ut 0·5 mm. and then curving and growing l to the tube surface and along the direction of The length of these whiskers was up to 90 mm., ight per cm. was 0·44 mgm., and the diameter from about 0·4 mm. at the point of attachment than 0·2 mm. at the growing tip. The rate of is appreciable, and can amount to more than per day. Examination of these whiskers under croscope showed them to be hollow (Fig. 1). analysis of various sections showed them to of magnetite (Fe_3O_4) or goethite ($\alpha FeOOH$) ixture of the two. A composite diagram based asurements of a large number of whiskers is in Fig 2.



. Longitudinal section of whisker. Dimensions in millimetres

following tentative mechanism for the formaf these whiskers is suggested. During the early of corrosion an adherent carbonate scale is down by the hard water, but this is not ntly complete or repairable, since the alkalinity y falls, to stifle corrosion completely, and corrokes place at local anodic points. In stagnant n localized corrosion commonly leads to the tion of a hemispherical dome of corrosion ct over a pit. It appears that under the ce of rapidly flowing water the symmetry of rm of corrosion product is disturbed, leading formation of a hollow cylinder bent through a angle in the direction of flow. Ferrous ions, d at the anodic area at the root of the whisker, along the tube, and growth of the whisker ds at the tip, where these ions are oxidized ecipitated as iron oxide on coming into contact he aerated water. The rate of ionic diffusion

may be increased by the suction induced
rapidly flowing water at the tip.

Mayne[1] has shown that rapid oxidation of
hydroxide at a pH value greater than 5 gives g
while slow oxidation leads to the formation
intermediate between magnetite and ferric
(γFe_2O_3). Thus the formation of goethite
present case is readily explained. The forma
magnetite, the second constituent, is not li
occur in the same area at the same time as g
since slow oxidation would appear to be nec
Therefore, the oxidation to form this compoun
occur in some areas sheltered from the direct
of the water. This may occur in pockets of
ion-containing water trapped in the goethite c
or by slow oxidation of the ferrous ion dur
passage through the whisker either by a small a
of oxygen contained in the water or by c
diffusing through the wall of the tubule.

This communication is published by permis
the Director of the National Chemical Labo
Teddington, Middlesex.

G. BUTLER
H. C. K.

National Chemical Laboratory,
Teddington, Middlesex. Sept. 5.

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Radiochromatography of Alkali Ion

IN their recent communication[1], Modreanu
and Carpov state "only three mixtures of sc
seem to have been proposed to accomplish the ch
tographic separation of potassium, rubidiur
cæsium". These methods being "tedious", th
nitrobenzene saturated with water as solvent f
separation of potassium, rubidium and c
spotted as picrates on Whatman paper No. 4. I
however, shown that an even larger range of
ions, namely, lithium, sodium, potassium, rub
and cæsium, could be separated employing a ma
simpler procedure[2]. This merely used acid-w
asbestos paper and dilute hydrochloric a
solvent. The use of radioisotopes as tracers, na
sodium-22, potassium-42, rubidium-86, cæsiur
both expedited and simplified the analysis c
chromatogram. In the case of lithium, howe
Perkin-Elmer flame photometer was used to dete
its *répartition*. The following R_F values were ob
for tracer to milligram concentrations of the dif
alkali ions with 0·1 N hydrochloric acid as solve
bands of asbestos paper 12 mm. wide, 25 cm
and 0·2 mm. thick.

Li^+	Na^+	K^+	Rb^+	Cs^+
0·99	0·86	0·77	0·72	0·45

Results on electromigration of ions in fused
showed that heavier ions tended to become '
preferentially on the asbestos paper used as su
This was confirmed by their chromatographic se
tion with the same solvent (dilute hydrochloric
on Whatman filter paper treated with 'Dow
following Lederer's technique[4], as also on s
ion-exchange resin-coated cellulose filter paper
plied by Carl Schleisser and Schül[2]. From
similarity of results it was shown that asl
functions as an ion-exchanger of feeble capaci

In the study of the isotope effect in the el
migration of a mixture of cæsium-131 and cæsiu
ions in fused sodium nitrate[5] this techniq
asbestos paper chromatography was used to c
cæsium free from sodium from samples initiall

due to the presence of the copper-to-copper linkage; (2) the polarization of the latter band is the reverse of the polarization of the former.

The present measurements indicate that cupric mono-, di- and tri-bromoacetates in dioxan have an absorption band at about 80 × 10^{13} c./s. besides an absorption band at about 40 × 10^{13} c./s., suggesting that all these compounds may contain the acetate-type binuclear molecules. The dichroism measurements, which have been carried out in the visible and ultra-violet region by Tsuchida and Kobayashi's microscopic method[2], indicate that cupric monobromoacetate monohydrate and anhydrate show absorption bands at about 40 and 80 × 10^{13} c./s. in addition to absorption bands in the far ultra-violet. Moreover, the polarization of the latter band is bound to be the reverse of the polarization of the former. These relationships bear a close resemblance to those with the cupric alkanoates, suggesting the existence of the binuclear molecules in organic solvents and in the crystalline state.

Similar characteristics have been observed in the absorption spectra of cupric di- and tri-bromoacetates. Thus the two compounds, anhydrous and hydrated, show absorption at about 40 and 80 × 10^{13} c./s., besides strong absorption in the shorter wavelength region. In addition, the polarization of the latter band is the reverse of the polarization of the former. It is certain that cupric di- and tri-bromoacetates consist of the binuclear molecules in the crystalline state and in organic solvents.

The difference between the tribromo- and trichloroacetates, as observed in the present work, may be regarded as due largely to the greater inductive effect of the bromine as compared with that of the chlorine.

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Paper Chromatography of Small Amounts of Vasopressins and Oxytocins

IN work concerned with the composition and estimation of neurohypophysial hormones in the posterior pituitary, the hypothalamus and body fluids, it would be desirable to have a chromatographic procedure which permits the identification in and recovery of small amounts of the active peptides from impure extracts. It would also be useful to know whether the substituted synthetic oxytocins which have recently been prepared[1] can be distinguished by a simple chromatographic method. Taylor[2] separated oxytocin, and arginine- and lysine-vasopressin by ion-exchange chromatography on resin columns. He used du Vigneaud's highly purified peptides, and the smallest amounts applied were equivalent to 0·6 mgm. of this material. Benfey[3] purified Stehle and Fraser's[4] preparations of ox posterior pituitary hormones (200 U./mgm. pressor activity and 250 U./mgm. oxytocic activity) by paper chromatography using ninhydrin as the colour reagent. The smallest amounts of the hormone preparations used were 1 mgm. However, since only terminal amino-groups react with ninhydrin, it is obviously disadvantageous to use this reagent when attempting to visualize very small quantities of the posterior pituitary peptides. Rydon and Smith[5] have shown that micrograms of peptides of all kinds, including cyclopeptides, can be detected by chlorination followed by spraying with a starch–potassium iodide solution. Reindel and Hoppe[6] improved this procedure in two ways. First, before exposure to chlorine, they moistened the paper with a mixture of watery ethanol and acetone, which prevents background staining. Secondly, they treated the N-chloropeptides with a mixture of potassium iodide and either benzidine or *o*-tolidine in acetic acid and thereby increased the sensitivity of the method.

We used Reindel and Hoppe's modification for the ascending chromatography of synthetic oxytocin, valine-oxytocin, phenylalanine-oxytocin, arginine-vasopressin and lysine-vasopressin. Other preparations used were 'Pitressin', 'Pitocin' and 'Pituitrin' (Parke, Davis and Co.) and simple acetic acid extracts of ox, hog and rat posterior pituitary glands and hypothalami. The paper employed was Whatman No. 1, the solvent was *n*-butanol/acetic acid/water (5 : 1 : 4), the length of flow was 24–48 hr. and the experiments were done at ambient temperatures. Owing to the small amounts of peptides used (see below) some of the spots faded rapidly. All chromatograms were therefore photographed immediately after development.

Areas on parallel strips, corresponding to spots obtained from reference preparations, were extracted with Ringer–Locke solution, and the activities in the eluates estimated by bio-assay. The isolated rat uterus was used for oxytocic assays; pressor activity was assayed on the blood pressure of rats anæsthetized with urethane and treated with dibenyline.

Fig. 1*a* shows a chromatogram of highly purified arginine-vasopressin and lysine-vasopressin, which were kindly supplied by Prof. van Dyke. (Saline containing chlorobutanol and acetic acid was the solvent used by van Dyke for the vasopressins obtained from du Vigneaud for pharmacological experiments. Since the sealed ampoules were heated before refrigeration, van Dyke believes that biologically inert spots in chromatograms of arginine-vasopressin represent degradation products not necessarily present in the original material, which was highly purified but not the purest which du Vigneaud and his associates have

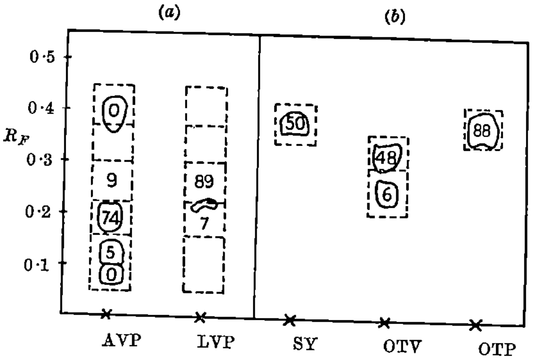

Fig. 1. Paper chromatograms of (*a*): arginine-vasopressin (AVP) and lysine-vasopressin (LVP), and (*b*): synthetic oxytocin (SY) ('Syntocinon', Sandoz), valine-oxytocin ('OTV 80', Sandoz) and phenylalanine-oxytocin ('OTP 79', Sandoz). Two strips of paper were chromatographed for each substance but only one was developed; the other was cut into pieces indicated by the broken lines. The pieces were extracted and the eluted activities were bioassayed. The figures within the columns indicate percentage recovery. The amounts (in mU.) applied at the origin *X* were: AVP, 800; LVP, 740; SY, 2,450; OTV. 300; OTP, 560

Table 1. R_F VALUES IN n-BUTANOL/ACETIC ACID OF VASOPRESSINS AND OXYTOCINS

Peptide	R_F
Arginine-vasopressin	0·19
Lysine-vasopressin	0·26
Oxytocin (synthetic)	0·37–0·40
Valine-oxytocin	0·33
Phenylalanine-oxytocin	0·37–0·39

isolated. The latter have previously commented on the instability of arginine-vasopressin.) Arginine-vasopressin gave more than one spot but the bulk of the pressor activity was found at R_F 0·19. Most of the pressor activity of ox-gland extracts was found at approximately the same R_F. In the case of lysine-vasopressin 89 per cent of the activity applied was found above the clearly stained area at R_F 0·26. Experiments with pig posterior pituitary extracts, in which larger amounts of the hormone could be applied, yielded a faint spot at the same region, which contained likewise most of the pressor activity. Valine-oxytocin (Fig. 1*b*) and 'Syntocinon' on 3 out of 6 chromatograms gave also an additional spot, which agrees with the statement of the makers that these preparations contain some inert material. Table 1 gives tentative R_F values for the active octapeptides.

The oxytocic activity of ox, pig and rat pituitary extracts was found in the same region of the chromatograms as that of synthetic oxytocin. The position of the pressor activity of rat gland extracts corresponded to that of arginine-vasopressin, which accords with the pharmacological evidence of van Dyke *et al.*[7], who found that the vasopressin of rat pituitaries behaves like arginine-vasopressin when injected intravenously into dogs. Ox hypothalamus yielded pressor and oxytocic activity at the R_F of arginine-vasopressin and synthetic oxytocin, but a marked discrepancy was noted between the colour intensity of the spots and the biological activity present in the eluates of the corresponding areas. For the present we cannot say whether this discrepancy is due to substances with a much lower potency than that of the glandular hormones or to the presence of inert material with very similar or identical R_F values as those of oxytocin and vasopressin.

Our results suggest that the colour intensity obtainable with the chromatographic procedure described varies considerably from one neurohypophysial peptide preparation to the other. For example, up to 1,500 mU. of synthetic oxytocin had to be applied to obtain a well-stainable spot, whereas 400 mU. of highly purified arginine-vasopressin (equivalent to about 0·7 μgm. of the pure peptide) were sufficient to give a spot of similar intensity. On the other hand, as little as 10 mU. (= approx. 0·02 μgm. peptide) of oxytocic or pressor activity could be eluted and assayed.

We are indebted to Prof. H. Konzett for providing the substituted oxytocins.

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Complex Forms of Cellulase

RECENTLY, several articles have been published on the multiplicity of cellulase. Using paper chromatography Jermyn[1] found eight components in cellulase from *Aspergillus oryzae*, each with cellulolytic activity. Reese and Gilligan[2] found, also with chromatographic techniques, three components in *Myrothecium* cellulase, whereas Miller and Blum[3], using starch electrophoresis, found at least eight components in this product. Grimes[4] isolated from *Myrothecium* cellulase six components, of which possibly three had cellulolytic activity, and Thomas[5] found seven protein fractions by paper electrophoresis. These facts are puzzling. Whitaker[6] succeeded in isolating a homogeneous protein from crude *Myrothecium* cellulase which exhibited all the activities of the crude product, so there is a possibility that cellulase is a single enzyme. However, this has never been confirmed.

Comparing cellulase with other depolymerizing enzymes, for example, amylases and pectinases, there is a possibility that the cellulose breakdown is brought about by several discrete enzymes, a possibility which is enhanced by experiments which show that the action on cellobiose is separable from other activities[7].

That the number of discrete enzymes would in this case be as great as is indicated by the results mentioned above seems improbable.

We therefore supposed that in a crude cellulase preparation the enzyme or enzymes might be bound to a number of metabolic products, thus giving rise to a large number of complexes with cellulolytic activity.

Consequently our efforts were concentrated on the search for a method by which these bound forms of cellulase could be split up. We think we have found the first step for this purification in using a special chromatographic technique.

A crude cellulase product was obtained by growing *Myrothecium verrucaria* on a cellulose – salts medium for 14 days. Culture filtrates were concentrated in a Bartholomew evaporator, dialysed, freeze-dried, dissolved in a small amount of water, centrifuged, ultra-filtered through collodion membranes (similar to that used for dialysis) and again freeze-dried. The resulting product was a light brown powder, and normal fractionation procedures with ammonium sulphate, alcohol or acetone proved unsuccessful with respect to separation of activity and colour.

The activity of this powder was estimated, using hydrolysis of carboxy methyl cellulose as a standard.

A 50 mgm. portion was placed on top of a column of Schleicher and Schüll cellulose powder, No. 123, which had been washed previously with distilled water to which had been added sodium hydroxide to give a *p*H of 11·0 (glass electrode). The loaded column was then percolated with the same solution. The effluent was collected in 2-ml. portions in tubes which had been filled with 2 ml. of buffer at *p*H 5·6. The enzyme activity of these was determined. Two fractions were obtained, the first containing all the coloured substances, the second a perfectly colourless solution.

The specific activity of the original material was 140 cellulase units per mgm. nitrogen. Activity of fraction 1 was 70 cellulase units, that of fraction 2 was 310 cellulase units. Preliminary dry-weight measurements on fraction 2 showed a four-fold increase in activity per mgm. dry-weight, while in fraction 1 this was diminished by a factor of three. Overall losses were rather low, about 75 per cent of the original activity being recovered.

The method was very sensitive to small alterations in the conditions. At pH 5, 6, 7, 8 and 9 no separation took place. At pH 12 great losses occurred, presumably due to denaturation. Increasing ionic strength by addition of small amounts of sodium chloride up to $0 \cdot 1\mu$ also prevented the separation.

Cellulose as a carrier seems to be indispensable, identical experiments on starch columns being unsuccessful.

The question arises as to how far formation of complexes affects the activity of the free enzyme. When larger amounts have been separated, experiments will be carried out to elucidate these phenomena.

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A Micro Sample Introduction System for Gas Chromatography

An ideal sample introduction system for gas chromatography suitable for use with a variety of columns and detection devices should possess the following characteristics: (1) the entire sample should be delivered to the inlet of the column as a vapour over a short time-interval to keep dilution of the sample with carrier gas at a minimum; (2) the samples delivered should be of reproducible quantity or, better, of precisely known quantity; (3) the introduction of sample should not necessitate stopping or changing the flow-rate of carrier gas; (4) the quantity of air introduced with the sample should be minimal.

With the availability of a variety of high-sensitivity detectors for gas chromatography, it has become possible to perform analyses using only a few μgm. of total sample. To take advantage of this increased sensitivity of detection, without the necessity for dilution and contamination of liquid samples with relatively large quantities of carrier liquid, an apparatus permitting the reproducible injection of known volumes in the μgm.-range was designed (Fig. 1). Samples are sealed into small glass capillaries in which the volume of liquid can be accurately measured, and introduction of the sample is achieved by crushing the capillary in the gas stream at the column inlet. There is little simultaneous injection of air, and it is not necessary to interrupt or change the flow of carrier gas at the time of introducing the sample.

The internal diameters of 1-cm. lengths of finely drawn glass capillary tubing are measured with a measuring microscope. The end of the section of tubing is applied to the surface of a liquid sample and allowed to fill partially. The capillary is shaken gently until the liquid sample occupies its central section, whereupon the ends of the capillary are sealed in a flame. The length of the column of liquid is measured with a measuring microscope and the volume of liquid then calculated. A capillary of $0 \cdot 1$ mm. internal diameter contains $7 \cdot 8 \times 10^{-6}$ cm.^{3} per mm. of length. In analyses using detection devices in which insensitivity to interruption of the flow of carrier gas permits easy access to the column inlet, the capillary may be dropped and crushed at the top of the column against a slotted plate provided for the purpose. For use with detection devices in which no interruption of the gas flow-rate is desirable, several simply constructed devices for the introduction of the capillary filled with liquid sample have been designed.

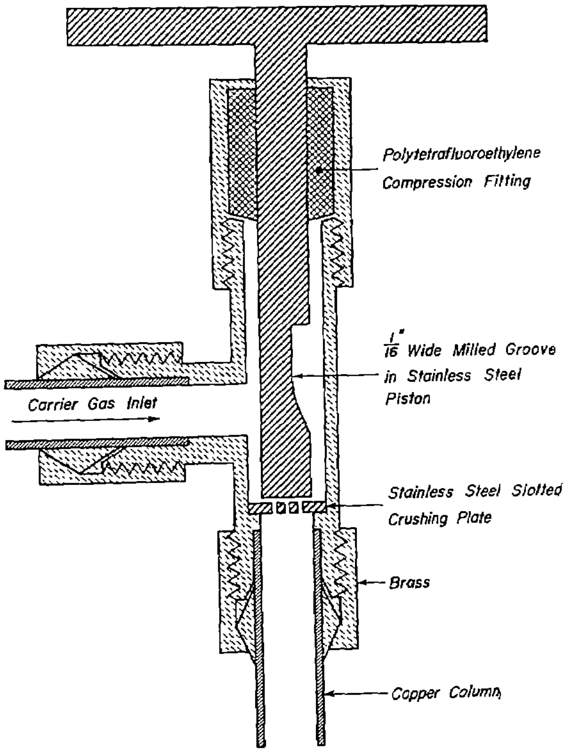
Polytetrafluoroethylene Compression Fitting
1/16" Wide Milled Groove in Stainless Steel Piston
Carrier Gas Inlet
Stainless Steel Slotted Crushing Plate
Brass
Copper Column

Fig. 1

The device consists of a vertical section of brass tubing with a side-arm, modified from a standard T-shaped copper tubing connector. A slotted plate is fixed in place over the column inlet at the lower end of the vertical section. Carrier gas enters the connector through the side-arm. A 1-cm. long groove is milled in the side of a stainless steel piston fitted into a sliding joint at the upper end of the vertical section. The joint is maintained leak-tight by means of a poly-tetrafluoroethylene compression fitting somewhat longer than the milled groove. In operation, the piston is moved upward to expose the groove above the fitting, the capillary filled with sample is placed within the groove, and the piston pushed down to its original position, with the groove in the gas stream. The capillary slides free of the piston coming to rest on the slotted metal plate below. The small quantity of air contained in the groove is permitted to pass through the column following which the capillary is crushed by the piston and the sample thus injected.

Because of the heat-resistant properties of polytetrafluoroethylene, injection of sample may be accomplished at temperatures high enough to permit rapid volatilization of the liquid. The small size of the sample reduces the size and heat capacity requirement of the surface from which rapid evaporation takes place.

Reproducibility of sample introduction was determined by comparing the calculated volumes of methyl laurate samples introduced into a chromatographic column with the response of the detector to each sample integrated with respect to time. The quotients obtained, measures of the apparent sensitivities of the detector, were reproducible to less than 10 per cent average deviation with volumes from 4×10^{-6} ml. to $0{\cdot}5 \times 10^{-3}$ ml.

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Physarosterol, a New Sterol from a Slime Mould

DURING the course of isolating the yellow pigment contained in the myxomycete, *Physarum polycephalum*, a second crystalline (colourless) material was obtained from the neutral ether extracts of the tissue. Analyses showed that this substance was probably a C_{30} sterol not hitherto found in Nature. It is proposed that the compound be referred to as 'physarosterol'.

Physarosterol was isolated by separately homogenizing three different batches of tissue (15–20 gm. each) in an hydraulic homogenizer[1] with three volumes of 0·007 *M* potassium arsenate buffer[2] (*p*H 7·0). The homogenate was acidified with sulphuric acid and a one-third volume of alcohol was added. After addition of filter aid, the slurry was filtered by vacuum. The yellow filtrate was saturated with sodium chloride, filtered, and continuously extracted with ether until no more pigment was carried over into the solvent. Then the ether extract was concentrated to 100 ml. at 60° C., made alkaline with 4 *N* sodium hydroxide solution and again extracted five times with ether (separatory funnel). The aqueous phase which contained the yellow pigment was stored for later processing. The nearly colourless ether solutions were combined and allowed to evaporate slowly at room temperature. Gradually a layer of lipid formed on the top of the solution and crystals began to be deposited on the bottom of the vessel.

When crystal formation had ceased, the lipid and underlying solution were decanted and the crystals removed by filtration. Approximately 25 mgm. of sterol were obtained from 100 gm. of tissue. Recrystallization was effected twice from a minimum volume of warm alcohol–ether (1 : 2). The crystals were dendritic leaves. The following analysis was obtained: calculated for $C_{30}H_{52}O_3$: C, 78·21; H, 11·39. (Calculated for $C_{30}H_{50}O_3$: C, 78·54; H, 10·98); found: C, 78·17; H, 11·31 $[\alpha]_D^{28}$ $-55{\cdot}3°$ (*c*. 0·5 in chloroform), melting point 137–139° C. (Fischer Johns apparatus).

The compound gave an immediate digitonide precipitate and an immediate lavender colour in the Lieberman–Burchard test (eventually a green precipitate was formed). Concentrated sulphuric acid produced an intense orange colour. Physarosterol gave no colour either with tetranitromethane or with ferric chloride. A bromine solution was immediately decolorized by a solution of the sterol in glacial acetic acid. A test for alkoxy groups was negative. No carbonyl band was observed in the 260–290 mμ region of the ultra-violet (*c*. 23 mgm./10 ml. in chloroform).

The closest fitting empirical formula for physarosterol ($C_{30}H_{52}O_3$) would allow for the presence of five-ring structures. The *ABCD* rings of the cyclopentenophenanthrene nucleus would account for four of these rings. In the absence of a carbonyl group, a fifth carbocyclic or methylene dioxy ring could be excluded because the evidence for a double bond accounted for the fifth ring structure. Furthermore, since the tetranitromethane test was negative, the double bond may have been sterically hindered and endocyclic.

Two attempts were made to acetylate physarosterol by exposing it to acetic anhydride and pyridine at room temperature for 24 hr. In both experiments, the parent compound was recovered unchanged. This difficulty suggested that the hydroxy groups were in juxtaposition to tertiary carbon atoms.

In summary, these results indicated that physarosterol was a C_{30}, unsaturated, trihydroxy sterol with one of its hydroxyl groups in the 3β position.

Because the isolation of this substance is incidental to other aspects of slime mould chemistry at present being pursued, it is not anticipated that any further work will be carried out in this laboratory in regard to its structure.

I am indebted to Mr. Ralph Karler of this department for providing generous samples of *Physarum polycephalum*.

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Inhibition of Pancreatic Deoxyribonuclease by Acidic Polymers

IN a recent publication the inhibition of pancreatic ribonuclease by a series of polymers possessing phenolic and carboxylic or sulphonic acid groups was compared with their action against influenza and vaccinia viruses in embryonated eggs. This communication describes the action of certain of these polymers on pancreatic deoxyribonuclease (Worthington Biochemical Corporation).

Enzyme activity was determined by the increase in optical density at 260 mμ of enzymatic digests at 29° ± 0·2° C. (Kunitz's method) in the presence or absence of graded inhibitor dilutions. The rates were computed from the linear portions of density – time graphs by the method of least mean squares, and by interpolation the inhibitor concentration reducing the rate to one-half of the control value (IC_{50}) was determined. The method permitted a reproducibility of rate measurements of ± 5 per cent in duplicate samples. While the absolute rate of the deoxyribonuclease reaction varied from day to day, this had no bearing on the IC_{50} values, which are relative figures, and were reproducible to ± 15 per cent or better. Table 1 shows the experimental conditions.

Table 1. Deoxyribonucleic acid solution (Worthington Biochemical Corporation): 400 μgm./ml. in 0·1 *M* acetate *p*H 5, 0·005 *M* magnesium sulphate, centrifuged and filtered. Deoxyribonuclease solution: 200 μgm./ml. in 0·1 *M* acetate *p*H 5

	Non-inhibited reaction (control)		Inhibited reaction	
	Blank	Digest	Blank	Digest
DNA solution	1 ml.	1 ml.	1 ml.	1 ml.
Water	4 ml.	3·5 ml.	3·5 ml.	3·0 ml.
DNase solution	—	0·5 ml.	—	0·5 ml.
Inhibitor ,,	—	—	0·5 ml.	0·5 ml.

Eighteen selected polymers were tested, representative of the following general types of polymerization: (1) phenolic carboxylic or sulphonic acids condensed with aldehydes; (2) polymers arising from the products of (1) on further condensation with phenolic acids under oxidizing conditions giving 'triphenylmethane' types; (3) oxidative polymerization of phenolic or hydroquinone-like compounds. In general, the half-inhibitory concentration for deoxyribonuclease was about three times that found for ribonuclease, under the conditions employed. The most notable exception was sodium humate from lignite, for which the ratio of IC_{50}-deoxyribonuclease to IC_{50}-ribonuclease was about 13. For the sake of comparison, heparin, sodium chitin sulphate and the polyurea from 4,4′-diaminodibenzyl-2,2′-disulphonic acid were also examined and found to agree with the above generalization, while suramin appeared to be weakly inhibitory at low, and seemingly accelerating at higher concentrations. The results for a few representative polymers are presented in Table 2. The results indicate that no noteworthy qualitative differences exist between the responses of the two nucleases to the acidic polymers investigated.

Table 2. INHIBITION OF RIBONUCLEASE AND DEOXYRIBONUCLEASE BY ACIDIC POLYMERS
(IC_{50}, half-inhibitory concentration)

Polymer	IC_{50} ribonuclease μgm./ml.	IC_{50} deoxyribonuclease μgm./ml.
Gentisic acid + CH_2O	2	4
Gentisic acid + $K_2S_2O_8$ + NH_3	3	10
(Gentisic acid + CH_2O) + HNO_2 + gentisic acid	1	3
Hydroquinone sulphonic acid + CH_2O	13	32
Anthranilic acid + $FeSO_4$ + H_2O_2	5	17
Hydroquinone + $K_2S_2O_8$	2	6

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Electron Microscope Studies of the Chemical Reactivity in Keratin Cuticle

DETAILED information about the structure of a cuticular layer of flat overlapping cells, covering animal hairs and wools, is of great technological importance. Its ratchet-like character is responsible for the greater frictional resistance to motion in the tip to root than the root to tip direction; and is one of the causes of felting.

The multilayer structure of an individual cuticle cell has been clearly established: on one hand, indirectly, from experiments involving mechanical and/or chemical fragmentation[1-5], and closely supported by some results of the work making use of high-resolution atomic replicas of wool fibres[6]; and, on the other, through a more direct method of ultrathin sectioning, combined with electron staining agents (osmium tetroxide) (refs. 7 and 8 and private communications by A. O. T. Charles and H. Mahl).

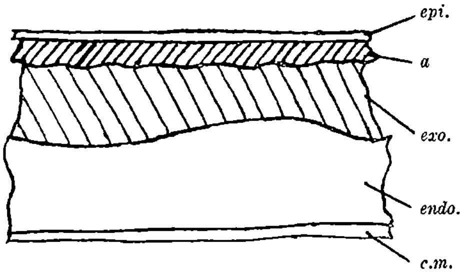

Fig. 1. Layer structure of keratin cuticle, after Lagermalm. *Epi.*, epicuticle; *a*, highly inert layer; *exo.*, exocuticle; *endo.*, endocuticle; *c.m.*, cell membrane

Thus it was concluded that immediately below the outermost thin membrane (called the 'epicuticle') there lies an easily stained thin layer (*a* in Fig. 1), resistant to both keratinolytic agents and enzyme digestion. This is followed by a keratinized layer (the 'exocuticle') which, in a fully hardened fibre, appears to show only a slight differential staining, relative to the lower cytoplasmic layer (the 'endocuticle'—insoluble in keratinolytic solvents, but attacked by enzymes), attributed to a higher concentration of sulphur in the former[8]. The character of the layer *a* is not clear; however, there can be little doubt that such a layer, if indeed present, will play an important part in determining the stability of fibres to the action of chemical agents, or such mechanical treatments as may be used to modify the frictional properties of wool in order to reduce the rate of felting.

In all these considerations an assumption was made that osmium tetroxide reacts strongly with cysteine or cystine[9]; and it occurred to us that, in order to obtain an independent confirmation of this view, use could be made of some metal salts known to form (coloured) metal sulphides in keratin[10-15].

The present investigations involved merino and Lincoln wools, mohair fibres, human hair, pig bristle and porcupine quill, which were treated either in mercury or lead salts[14,15]. In the latter case, keratin specimens were treated, for a period of up to 18 hr., in aqueous sodium plumbite solutions, at 35° C. and *p*H 11·8, at a concentration equivalent to 0·1 per cent lead nitrate[14]. Following this treatment, the specimens were washed for 12 hr., first in water at 35° C. and then in running cold water. The ultrathin sections (about 200 A. in thickness) were obtained on a commercial Philips ultra-microtome (fitted with a glass knife, 45°), using 'Araldite' as an embedding medium[16].

Fig. 2 shows the differentiation of layers in the cuticle of pig bristle, in agreement with the scheme of Fig. 1, but more clearly than in the experiments involving osmic acid (refs. 7 and 8 and private communications by A. O. T. Charles and H. Mahl). X-ray diffraction photographs of the bulk of fibres confirm the formation of lead sulphide, and there can be little doubt that the dark spots visible throughout the cross-section are related to this compound.

We are aware that some aspects of the detailed interpretation of results obtained by this method are still uncertain (such as a possibility of migration

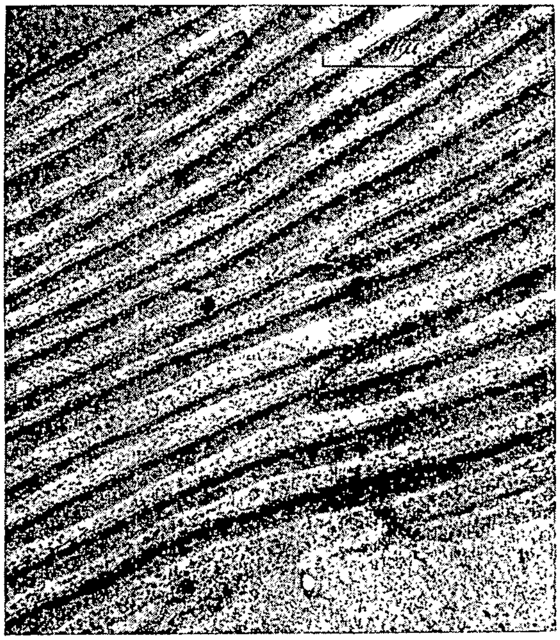

Fig. 2. An electron micrograph of a cross-section of pig bristle, after treatment in sodium plumbite. Note: the outermost cuticle cell, in top left-hand corner; and the cortex, in bottom right-hand corner. Direct print from the original (× c. 20,700)

during the formation of metal sulphides), and further experiments are in progress to clarify this and other points. Nevertheless, we believe that, even at this early stage, the workers in this and some allied fields may be interested to have their attention directed to the efficacy of our method of detecting the distribution of active groups in keratin with heavy metals, providing, thereby, a greater degree of electron contrast (though qualitatively estimated at present) than that obtained with metal atoms normally used in the practice of electron staining[17].

One of us (W. S. S.) wishes to thank the New Zealand Defence Scientific Corps for a grant which enabled this work to be carried out.

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A Galactan from *Mycoplasn*

Little is known of the carbohy
plasma mycoides var. *mycoides*, t
sponsible for bovine contagious
(This is the nomenclature used b
E. G. D. Murray and N. R. Smit
edition of "Bergey's Manual of
Bacteriology", p. 1. (Williams a
Baltimore, 1957). We use the
mycoides in what follows. The or
widely known in the past as *Astero*
Kurotchkin[1], however, was able t
logically active fraction which gave
and negative biuret reactions. We
the strain (*V*5) of *M. mycoides* used i
for the preparation of bovine co
pneumonia vaccine, with the obj
material which might be of value i
studies.

The organisms were grown in *B*
inoculated with 5–8 ml. of a 4-day
After incubation of 24–28 hr. in
37° C. they were harvested in a stean
supercentrifuge and washed in col
chloride, and in cold distilled wa
washed organisms were hydroly
sulphuric acid and the hydrolysates
in four solvent systems, galactose
the only sugars detected. Gluc
amounted to less than 3 per cent of
The identity of galactose was confir
tion of the α-methylphenylhydrazor
for the presence of amino-sugars,
heptoses could be obtained by th
colorimetric tests[3]. The washed
found to contain approximately 10
dry weight as carbohydrate when
anthrone procedure of Trevelyan
using galactose as the standard.

Washed suspensions were frozen
times, buffered to *p*H 8 by the
hydroxymethylaminomethane to a
0·04 *M*, and centrifuged at 26,000
rotor 40 of the 'Spinco' preparativ
model *L*. The galactose was almo
sedimented while most of the
remained in the supernatant. Th
tracted with warm aqueous phenol
method of Westphal *et al.*[5]. The aq
tained a polysaccharide together
nucleic acid. This solution was dial
with respect to acetate (*p*H 8) an
105,000*g* for 4 hr. The polysacch
more rapidly than the ribonuclei
almost completely freed of the la
three centrifugations. Ribonucleic
be removed by passing the dialysed
through columns of 'Dowex-1' chl
cross-linked). This method was mor
ultracentrifugation and gave higher

The polysaccharide contained sn
amounts of nitrogen (0·2–0·8 per
of phosphorus ($< 0·1$ per cent).
in 0·5 *N* sulphuric acid for 2 hr. at
cent of the material was accounte
sugar (calculated as anhydrohexose
the only sugar detected on paper
The polysaccharide was not pyroge
into rabbits. It gave positive pr
with *M. mycoides* antisera, sensitize

agglutination by the antisera and itself inhibited the agglutination of sensitized erythrocytes by the antisera (Cottew, G. S., unpublished observations). It thus has the properties of a complex hapten. No antibody formation could be detected following injections of the galactan into rabbits. Its relationship to the soluble antigens recently reported by White[6] is not known.

We are grateful to Mr. N. M. Semple of the Commonwealth Serum Laboratories for carrying out pyrogen tests, and to Drs. A. W. Turner and A. W. Rodwell of this laboratory for their support and interest.

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Formation of Ketones from Fatty Acids by Spores of *Penicillium roqueforti*

From time to time during the past decade attempts have been made in this laboratory to determine the mechanism by which the mould *Penicillium roqueforti* produces the flavouring and aromatic compounds characteristic of the blue-veined cheeses, Roquefort, Stilton, Gorgonzola and 'Bleu'. These aromatic compounds are a family of ketones, each one produced from a specific fatty acid which is one carbon longer, the carboxyl carbon, than the ketone. Thus the mould converts caprylic (octanoic) acid to 2-heptanone, caproic (hexanoic) acid to 2-pentanone, and so on. The overall kinetics for the conversion of fatty acids to ketones by *P. roqueforti* was published in 1955[1]; however, the individual steps in the conversion were not known. Until recently, the occurrence of the reaction under controlled conditions in the laboratory has been most erratic and unpredictable, not at all commensurate with the apparent reliability of the reaction in the manufacture of blue-veined cheese.

In attempts to study the reaction, young actively growing mould cells have always been used since, in all our work on the metabolism of filamentous fungi, such cells have much higher levels of metabolic activity. However, after a time it became apparent that the older cells were somewhat more reliable in ketone production and that the medium in which the cells were grown considerably influenced the reaction. A completely synthetic medium that provided excellent cell growth with no sporulation in submerged culture was developed[2], but mould cells grown on this medium completely lacked the ability to form 2-heptanone from octanoic acid. The formation of 2-heptanone has been used as a measure of the overall ability of the cells to form ketones from fatty acids and a chemical assay for 2-heptanone has been devised. Small amounts of corn steep liquor, protein hydrolysates and certain amino-acids when added to the synthetic medium caused the cells to sporulate, but these cells rapidly formed 2-heptanone when octanoic acid was added; it soon became evident that sporulation was a requisite for ketone formation and that the rate of ketone formation was directly proportional to the degree of sporulation. Even more surprising was the finding that it was indeed the spores that were forming the ketone and not the mycelium. Studies on the kinetics of the reaction using spores separated from the mycelium by filtration through pads of glass-wool show a direct relationship between oxygen uptake and ketone formation; all the oxygen taken up is used in ketone formation and the spores do not germinate. Spores that have been allowed to germinate or form even the smallest germ tubes cannot form ketones. Details on the kinetics and stoichiometry of the conversion of fatty acids to 2-ketones will be published elsewhere.

These findings implicate the spores of *P. roqueforti* in a series of reactions seemingly quite removed from dormancy and germination. Immediately one wonders if other mould spores, like these, might not have physiological possibilities that are now unknown or are ascribed to the vegetative cells.

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Biological Potency of Eta-Tocopherol

η-Tocopherol was first isolated from rice by Green and Marcinkiewicz[1]. DL-η-Tocopherol has been synthesized by McHale *et al.*[2]. In a preliminary report to the fourth International Congress of Nutrition, Bunyan *et al.*[3] gave the potency of η-tocopherol as less than 5 per cent of α-tocopherol.

A full-scale gestation resorption assay of DL-η-tocopherol has now been completed. Virgin Norwegian hooded rats, depleted of vitamin E for five to seven months, were mated and received oral doses in equal portions on the seventh and eighth days of pregnancy, being dissected on the eighteenth day. Results from rats with less than five implantation sites were ignored and the presence of two live fœtuses was taken as the minimum positive response. Forty-five dosed rats provided the assay results, and eight undosed controls all gave negative responses. DL-η-Tocopherol was found to have 3 per cent of the potency of DL-α-tocopheryl acetate (limits of error $0{\cdot}5$–$5{\cdot}4$ per cent, $P = 0{\cdot}05$).

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Differences between Duplicate Assays of Human Urinary Gonadotrophins

Sheps and Munson[1] have shown how the internal statistics of a single hormone assay may underestimate the variation actually observed on replication of that assay. Inter-assay errors may therefore be important when demonstrating qualitative differences between two hormone preparations by the simultaneous use of two different methods of assay. Such differences have been shown in human urinary gonadotrophins[2], and the errors between duplicates of the assays used have therefore been investigated.

The assays were for (*a*) total gonadotrophin, using the uterine response in immature mice, and (*b*) follicle-stimulating hormone, using the ovarian response in similar mice treated with excess human chorionic gonadotrophin[3]. Pairs of extracts obtained from human urine by the kaolin–acetone method were selected only on the grounds of availability and the fact that they had previously been assayed against one another. They were then re-assayed under the conditions described below, which were arranged so that inter-assay errors were likely to be maximal.

The coded solutions were made up by the same person but were assayed by different persons on the two occasions. In the second assay the dose-levels were designed to be as different from the original ones as was practicable. In five pairs of assays for total gonadotrophin the initial assay was calculated from quantal data and the second from the graded response. From one to seventeen months elapsed between the initial and second assays to allow for effects of storing the extracts. In assaying follicle-stimulating hormone a different batch of chorionic gonadotrophin was used in each assay of a pair.

The results of the assays using graded responses were calculated using log organ weight as the response metameter. Examination of the untransformed results pooled for each method of assay showed an obvious correlation of variance with response in both. The use of log-response stabilized variance satisfactorily in both assays, and such a transformation seems desirable in calculating the results of these assays.

Tables 1 and 2 show respectively the results of ten pairs of assays for total gonadotrophin and ten pairs for follicle-stimulating hormone. In the majority of the duplicate assays the results agree well. The fiducial limits ($P = 0{\cdot}95$) are similar in range to those which have to be used in practice[2], and in two of the twenty cases the limits of the two estimates do not overlap. These cases show significant inter-assay errors and suggest that the failure of the limits to overlap should not be used alone as evidence of significant differences between the results of two assays of a gonadotrophin. The degree of difference of the best estimates must also be taken into account and in only one case in these twenty duplicates does the ratio of the two estimates reach a value of two.

Table 1. Duplicate Assays of Total Gonadotrophin

Pair	Months between assays	Number of dose-levels		Percentage potency (95 per cent fiducial limits)		Ratio of potency estimates
		1st	2nd	1st	2nd	
1	1	2+2	2+3	72 (48–96)	92 (65–125)	1·28
2	1	2+2	2+2	348 (296–408)	238 (208–274)	1·46
3	4	2+2*	3+3	80 (49–115)	72 (53–119)	1·11
4	2	2+2	3+3	84 (56–117)	79 (43–116)	1·06
5	2	2+2	2+3	119 (70–232)	96 (74–124)	1·24
6	15	3+3*	3+3	82 (63–112)	71 (54–90)	1·15
7	15	3+3*	2+3	23 (17–31)	11 (7–15)	2·09
8	1	2+2	3+3	51 (34–72)	57 (51–69)	1·12
9	13	3+3*	2+2	114 (86–167)	100 (85–133)	1·14
10	13	3+3*	2+3	75 (52–114)	59 (35–76)	1·27

* Calculation from quantal data.

Table 2. Duplicate Assays of Follicle-Stimulating Hormone

Pair	Months between assays	Number of dose-levels		Percentage potency (95 per cent fiducial limits)		Ratio of potency estimates
		1st	2nd	1st	2nd	
11	2	2+2	2+2	292 (176–440)	154 (32–270)	1·90
12	11	2+3	3+3	27 (20–38)	29 (17–49)	1·07
13	11	2+3	2+3	17 (12–23)	9 (4–16)	1·89
14	10	2+3	2+3	986 (694–1,370)	735 (508–971)	1·34
15	12	2+3	2+2	848 (633–1,140)	877 (763–1,040)	1·03
16	1	2+3	2+3	264 (168–413)	266 (140–440)	1·01
17	4	2+2	3+3	1,620 (952–3,920)	1,810 (1,260–2,740)	1·12
18	17	2+2	2+3	67 (34–114)	95 (68–113)	1·42
19	2	3+3	3+3	15 (10–22)	15 (6–27)	1·00
20	8	2+2	3+3	2,600 (1,780–4,880)	4,800 (2,790–11,700)	1·85

The magnitude of the inter-assay error is roughly similar for the two methods. It is therefore likely that when a gonadotrophin is assayed by each method a similar error will occur between the two estimates of potency. The conditions of the present experiment were designed to accentuate inter-assay errors and a two-fold difference in estimates occurred only once in twenty pairs. If, therefore, the two methods of assay under normal conditions give estimates which show a more than two-fold difference, and the fiducial limits of which do not overlap, it is very likely that these results demonstrate a genuine qualitative difference. This is being used as a rough working principle until more precise analyses of these and similar data are available.

We are grateful to Dr. A. C. Crooke and Dr. W. R. Butt, and to other participants at the 1957 meeting of the Gonadotrophin Club for discussions on this topic. One of us (P. S. B.) is supported by the Medical Research Endowment Fund of the United Birmingham Hospitals.

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Concentration in the Human Ovarian Follicular Fluid of Radioactive Tracers and Drugs circulating in the Blood

The potential hazard of genetic changes induced by radioactive substances and of mutagenic and radiomimetic action of non-radioactive compounds is of current interest. Information, however, as to the intimacy of contact of these substances, when introduced into the human body, with the reproductive cells, particularly the ovum, is scant.

It has been well established that many radioactive tracers, compounds and drugs are transferred from the vascular into other compartments of the human body. However, it is not known whether in the human these substances are transferred into the ovarian follicular fluid. Since the follicular fluid surrounds the ovum and corona radiata and the egg might depend for its nutrition on this material, a transfer of exogenous substances into the ovarian follicular fluid might bring potentially noxious material into close proximity with the ovum or, by means of the cells of the corona radiata, into actual contact with the egg.

Previous animal studies[1-5] with sulphur-35 and to a lesser extent[6] with phosphorus-32, as well as with the dyes, trypan blue[7] and Evans blue[8], have shown the appearance of all of these compounds in the ovarian follicular fluid. Thus, beta-emitting radioisotopes have already been shown in animals to accumulate in an area where they may potentially do harm. Damage to the offspring has been described when the ovaries of intact animals were briefly exposed to a carcinogenic substance[9].

Our particular interest in this problem stemmed from our observations in a related field—intravenously administered iodine-131 and sodium thiocyanate–^{35}S, were rapidly excreted with and concentrated in the human cervical mucus. Their concentrations in mucus were many-fold higher than those obtained in blood[10]. As the next step in this investigation of the accumulation of exogenous material within the human female genital tract, the possible appearance of such material in the follicular fluid was investigated.

These studies were performed in twenty-nine premenopausal women undergoing hysterectomy, the principal indications for this procedure being cystocœle, menometrorrhagia or myomata. Eight patients received two different drugs simultaneously. None showed any gross abnormality of ovarian structure or function. The ovaries were exposed during surgery and the follicular fluid aspirated by puncturing a prominent follicle with a 25-gauge hypodermic needle attached to a tuberculin syringe. A venous blood specimen was drawn simultaneously. Whenever possible, a segment of the punctured follicle was removed for histological examination. Follicular fluid and blood were examined immediately. The following materials—iodine-131, iodine-131-tagged human gamma-globulin, mercury-203-tagged mercaptomerin, carbon-14-tagged meprobamate, penicillin and 'Pyridium' were given before hysterectomy by the route and at the time-intervals indicated in Table 1.

Table 1. THE RELATIVE CONCENTRATION IN HUMAN OVARIAN FOLLICULAR FLUID AND SERUM OF RADIOACTIVE TRACERS AND DRUGS

Drug and route of administration	No. of observations	Interval at which specimen obtained (hr.)	Ratio : Follicular fluid / Serum Mean	Range
^{131}I (intravenous)	7	0·25–7	0·44	0·14–0·97
^{131}I (intravenous)	7	12–60	1·13	0·60–1·62
^{131}I-human gamma-globulin (intravenous)	6	13–21	0·45	0·09–0·81
^{203}Hg-mercaptomerin (intravenous)	3	11–12	14·18	4·20–19·70
^{14}C-meprobamate (per os)	4	2·5–11	1·03	0·59–1·40
Penicillin (intramuscular)	4	2–4·5	0·33	0–0·50

Iodine-131 and mercury-203 activity were determined by gamma counting with a well-type scintillation counter, and carbon-14 was measured by beta-assay with a windowless flow counter. Penicillin concentration was determined from the bacteriostatic activity of the samples. Qualitative tests were employed to detect the presence or absence of 'Pyridium' in the follicular fluid. The results are expressed as the ratio of the relative concentrations of the test materials in the follicular fluid and serum.

The results show that all the compounds tested, iodine-131, iodine-131–gamma-globulin, mercury-203–mercaptomerin and carbon-14–meprobamate, penetrate from the blood stream into the human ovarian follicular fluid (Table 1). The results from the studies with iodine-131 show that penetration commences within 15 min., and the results with iodine-131–gamma-globulin suggest that a large molecule can pass into the follicular fluid at a slower rate. Of particular interest is the appearance in the follicular fluid of a mercurial diuretic agent and of a tranquillizer. 200 mgm. of 'Pyridium' was given orally 3–19 hr. before puncture of the follicle in six patients; the drug was detected in the follicular fluid in every instance.

Sixteen histological preparations were obtained; six of them revealed fresh corpora lutea from which tertiary follicular fluid had been obtained. The results are not sufficiently extensive to show any difference in the concentration of substances in the fluid from normal follicles as compared with that from the young corpora lutea. Our previous observations[10] have shown, however, that the ratio for iodine-131 is very low for large pathological ovarian cysts.

The results indicate not only that administered compounds penetrate into the human ovarian follicular fluid but that they may be concentrated therein. This property might be particularly significant when exhibited by drugs with mutagenic and radiomimetic effects or with the capacity to interfere with enzyme systems of the ovum, particularly during division. It is not known whether drugs present within the follicular fluid can do harm to the ovum, especially when administered over a long period of time, or at a particular stage in its development, such as when the ovum is dividing.

These studies suggest that the human egg *in situ* within its own follicle is exposed to therapeutic agents introduced into the general circulation. We are at present attempting to determine whether such materials appearing in the ovarian follicular fluid actually penetrate into the egg proper.

We wish to express our gratitude to Dr. E. Stewart Taylor for making this study possible, to Dr. Robert Dean for obtaining the surgical specimens, and to Dr. Stuart G. Dunlop for performing the bacteriological tests.

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Effect of Nitrous Oxide on the Radiosensitivity of Mouse Ehrlich Ascites Tumour

It has been shown that inert gases at pressures higher than 1 atm. reduce the oxygen-dependent radiosensitivity of the broad bean (*Vicia faba*) root and of mouse Ehrlich ascites tumour cells in the presence of oxygen[1]. The effectiveness of the inert gases follows their partition between water and lipids and is paralleled by their anæsthetic potency. It therefore seemed of interest to test nitrous oxide. Results obtained with nitrous oxide on mouse Ehrlich ascites tumour cells show a marked effect, and, since this gas is effective in the range physiologically tolerated by mammals, it seems worth while reporting the results (Table 1).

Table 1

Experiment	Gas mixture during exposure to X-radiation	Dose in r. to reduce normal anaphases to 31·6 (per cent)	Relative radiosensitivity
1	1 atm. of air	130 ± 10	3·5 ± 0·09
2	0·2 atm. of oxygen + 0·8 atm. of nitrous oxide	500 ± 20	0·91 ± 0·02
3	1 atm. of air + 95 atm. of argon	455 ± 20	1·0 ± 0·04
4	1 atm. of air + 11 atm. of nitrogen	330 ± 15	1·4 ± 0·02
5	1 atm. of air + 2 atm. of xenon	380 ± 15	1·2 ± 0·02

The experimental techniques and the method of evaluation of the results are those described previously[1], except that in Experiment 2 the tumour was fixed 12 hr. after irradiation because the maximum damage occurred then and not after 18 hr., as was the case in the other experiments.

It can be seen from Table 1 (Experiment 1) that the relative radiosensitivity of mouse ascites tumour cells, when exposed to 190-kV. X-radiation in 1 atm. of air, that is, 0·2 atm. of oxygen and 0·8 atm. of nitrogen, was 3·5 ± 0·09. The addition of 0·8 atm. of nitrous oxide to 0·2 atm. of oxygen (Experiment 2) reduced the radiosensitivity to the same extent as 95 atm. of argon (Experiment 3), that is, to the same low level as observed in irradiation under nitrogen alone[1]. Table 1 also shows the results of experiments carried out with the mixtures 1 atm. of air plus 11 atm. of nitrogen (Experiment 4), and 1 atm. of air plus 2 atm. of xenon (Experiment 5). These indicate that nitrous oxide is the most effective of the gases tested in blocking the effect of oxygen on the radiosensitivity of Ehrlich ascites tumour cells.

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Acclimatization Status of Temperate-zone Man

When men accustomed to living in a temperate climate are repeatedly or continuously exposed to a natural or artificial hot environment they rapidly develop a greatly increased capacity to withstand heat, and this adaptation is accompanied by profound and readily demonstrable physiological changes. On the other hand, when men are similarly transferred from a temperate to a cold, even arctic, environment
neither do they display the same
tolerance of their new environment n
found possible to demonstrate com
physiological changes. Such marke
been demonstrated are, in general,
such as the diminution in finger nu
by Mackworth[1].

This is a puzzling state of affairs,
seem logical to expect that men
ability to adapt to cold comparable
adapt to heat. The difficulty appe
the assumption that a temperate c
the neutral state in which environn
a minimum and that divergence f
cooler or to warmer conditions, is
an increasing physiological strain.

In order to determine the n
condition for man he must be
animal; that is, in a situation in
clothes, fire and shelter, he is able
undue physiological strain both dur
the very moderate energy expe
gathering is punctuated by occasi
expenditure in such crises as fligh
during the inactive hours of darkn
such circumstances it would appea
suited to the warm, equable environ
forest, with its small diurnal variati
and the protection it affords fro
solar radiation during the day
radiation to a clear sky at night.

As Martin[2] and others have sh
physiological evidence can be mar
of this view. Man's scanty ha
insulation. His capacity for pro
vasodilatation and his unequalled
(which are not matched by compa
for heat conservation) together pr
heat loss adequate, even in a war
for his usual moderate rate of energ
also for the high rates of relatively
The critical temperature for nake
is at the upper end of the range fo
which means that he requires
environmental temperature for
Macintyre[4] has stated that the te
the sheets of an occupied bed in
between 27 and 29° C. within a few

The most convincing evidence, h
the position of the neutral state
ment is provided by direct experim
It has been shown that Europea
adapted to life in a temperat
after a period of some eighteen
Singapore, an ability to work in
markedly superior to that of sim
England[5], and equal to that poss
genous Malay, Chinese and In
Such Europeans naturally acclima
environment do not, however, poss
adaptation to heat, for exposure
tures in a climatic chamber rapid
enhanced heat tolerance[7]. It is
living in the tropics are capable
range of adaptation both to ho
conditions.

It is to be concluded, therefore
climate does not represent the n
which environmental stress is
which adaptation is possible bot
colder conditions to an equal de

trary, man in a temperate climate is approaching the extreme range of adaptation to cooler conditions —that is, maximum adaptation to cold. It follows that it is fruitless to attempt to demonstrate profound physiological changes in temperate man on exposure to severe cold because, the greater part of the possible adaptation in this direction having already been made in a temperate climate, any further changes must necessarily be small.

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Extra-Regional Oocytes in Teleosts

THE occurrence of extra-regional oocytes has been described by several authors in many species of vertebrates[1,2]. Most of these cases related to the genital and the caudal region.

We have observed extra-regional oocytes in the following species: *Phenacogrammus interruptus*, *Chaetodon capistratus*, *Abramites microcephalus*, *Ballistes undulatus*, *Botia modesta*, *Cottus gobio* and *Barbus gelius*. These cases are summarized in Table 1. In general, the cells had the characteristic oocyte structure, namely, granular cytoplasm, oolemma, nucleus with several nucleoli.

The presence of extra-regional oocytes is closely related to the migration of the primordial germ cells. Obviously certain cases may provide important data on the mechanism of the migration.

For the three major theories relating to the migration of the primordial germ cells we refer to the publication of Johnson[2], who observed an amœboid movement in the germ cells of the black bass. Newth[3] stated that in Lacertilians the migration of the primordial germ cells to the gonadal ridges occurs by a definite route. This type of migration has already been known for a long time in lizards and in *Sphenodon*.

Concerning our case of extra-regional oocytes in the brain of *Abramites* it may be difficult for the primordial germ cells to reach the brain (mesencephalon) by Johnson's[2] first two types of migration, for this would involve crossing a great number of obstacles and carrying the cells a long distance. Like the extra-regional oocytes in the brain of *Cirrhina reba*[4], it is therefore very likely that in this case the migration of the germ cells takes place via the vascular route as in *Sphenodon*, the Lacertilians and the birds. These oocytes might have been lost while they traversed the brain region during their migration, after which they could settle in the brain tissue.

The case of the lordotic *Botia* suggests that the presence of the extra-regional oocytes and the degeneration of these cells are a consequence of the embryological disturbances in the caudal region. It is possible that these processes have passed to abnormal places.

It is noteworthy that in the case of *Ballistes* nucleolar extrusion was observed. The tumour in *Barbus* shows that migrated extra-regional oocytes which have migrated can proliferate under certain circumstances.

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Table 1. CASES OF EXTRA-REGIONAL OOCYTES IN TELEOSTS

Species	Localization of the oocytes	Extra-regional oocytes	Nuclei of the extra-regional oocytes	Remarks
Phenacogrammus interruptus (length 69 mm.)	Intermuscular connective tissue of the caudal region	Small, medium-sized and large types; infiltration of some large oocytes by strands of connective tissue	Several nucleoli	Externally no peculiarities
Chaetodon capistratus (length 78 mm.)	Intermuscular connective tissue of the caudal region	Medium-sized and large types; some oocytes degenerated	Several nucleoli	Externally no peculiarities
Abramites microcephalus (length 53 mm.)	Brain (mesencephalon)	Small and medium-sized types, sometimes attached to the brain tissue; infiltration of some medium-sized oocytes by strands of nervous tissue	Several nucleoli	Externally no peculiarities
Ballistes undulatus (length 83 mm.)	Intermuscular connective tissue of the caudal region	Small, medium-sized and large types	Several nucleoli, sometimes nucleolar extrusion	Externally no peculiarities
Botia modesta (length 89 mm.)	Intermuscular connective tissue of the caudal region	Small and medium-sized types; some oocytes degenerated but not infiltrated by strands of connective tissue	Several nucleoli	Lordosis
Cottus gobio (length 241 mm.)	Intermuscular connective tissue of the caudal region	Small, medium-sized and large types	Several nucleoli	Externally no peculiarities
Barbus gelivs (length 70 mm.)	Caudal region	No true extra-regional oocytes, probably developed to granulosa cell tumour	—	Irregular, nodular tumour

Conversion of Carbon-14 Dioxide to Starch Glucose during Photosynthesis by Spinach Chloroplasts

THE distribution of carbon-14 in the glucose moiety of sucrose, glucose phosphate and starch formed from carbon-14 dioxide during short-time photosynthesis in *Chlorella* and the leaves of higher plants has been shown to be asymmetric[1]. It was proposed that either glucose was not formed by the condensation of two triose phosphates of similar tracer distribution or that a pool of unlabelled dihydroxyacetone phosphate was present in the cell, causing a dilution of the upper three carbon atoms of the hexose. To test the validity of the latter suggestion, the intact spinach chloroplast free of much cytoplasic material was employed.

In agreement with Allen *et al.*[2], a glucose polymer was the only insoluble product formed under the conditions used. In the 4-min. experiment, the insoluble fraction accounted for 3 per cent of the tracer assimilated while in the 30-min. photosynthesis this fraction increased to approximately 20 per cent.

All the glucoses formed by the spinach chloroplasts during these time periods possess an asymmetric distribution of carbon-14 (Table 1).

Table 1. THE DISTRIBUTION OF CARBON-14 IN STARCH GLUCOSE FORMED BY SPINACH CHLOROPLASTS DURING PHOTOSYNTHESIS IN CARBON-14 DIOXIDE

Exp. No.	Time of exposure	Tracer content of carbon atom number (mμc./mgm. carbon)					
		1	2	3	4	5	6
1	3 min.	0·04	0·01	0·09	0·17	0·05	0·04
2	4 min.	1·02	0·69	1·54	2·42	0·46	0·55
3	30 min.	1·57	1·40	2·14	2·33	1·14	1·10

Chloroplasts were isolated in 0·35 *M* sodium chloride[2]. Unwashed chloroplasts were used in Exps. 1 and 2. Chloroplasts once washed with 0·35 *M* sodium chloride were used in Exp. 3. Warburg vessels (150 ml. capacity) contained the following components (in μmol.) : *tris* (hydroxymethyl) aminomethane buffer, *p*H 7·5, 80 ; sodium ascorbate, *p*H 7·5, 10 ; manganese chloride, 2 ; chloroplasts (5–10 mgm. chlorophyll) suspended in sodium chloride, 1,540. In Exps. 1 and 2, the mixture contained $NaH^{12}CO_3$, 48 and 5 μmol. respectively. In Exp. 3 the carbon-12 dioxide was negligible. The total volume was 4·8 ml.

The side-arm carried 1 μmol. of carbon-14 dioxide as sodium bicarbonate containing in μc. : Exp. 1, 100 ; Exp. 2, 150 ; Exp. 3, 10. After the vessels were flushed with prepurified nitrogen in a bath at 14° C. for 10 min. with the lights on (4,000 foot-candles), the isotopically labelled sodium bicarbonate was tipped in. The light source was Sylvania Birdseye Floodlites (150 watts, 120 volts). The reaction was terminated by heating the cup contents in a boiling water bath for 2 min. After the residue was washed twice in the centrifuge tube with hot water, the starch glucose was derived by hydrolysis with 6 ml. of 1 *N* hydrochloric acid for 45 min. at 100°. The mixture was centrifuged and the residue was washed twice with hot water. The supernatant fluid and washings, brought to approximately *p*H 7·5, were passed through 'Dowex-50' (H^+ form) and 'Amberlite *CG*–45' (OH^- form). The effluent was evaporated to approximately 1 ml. and streaked on to washed sheets (14 cm. × 17 cm.) of Whatman No. 1 paper. The chromatograms were developed with butanol (52 ml.), 95 per cent ethanol (32 ml.) and water (16 ml.). The X-ray film showed only one band with an R_F value corresponding to glucose. This band coincided with the typical hexose colour developed after aniline phthalate spraying. This glucose, together with 400 μmol. of carrier glucose, was degraded with *Leuconostoc mesenteroides*[3]. Activity is expressed in Table 1 as mμc. per mgm. of carbon.

The ratio of carbon atom 3 to carbon atom 1 (C-1, aldehyde carbon) and/or C-2 is less than that of C-4 to C-5 and/or C-6. This type of labelling pattern is similar to that reported by Gibbs and Kandler for glucose formed in intact cells[1]. It would appear that the cause of asymmetry is probably not a relatively large supply of unlabelled dihydroxyacetone phosphate.

The similarity between the tracer pattern of the starch glucose formed by the intact cells and isolated chloroplasts further strengthens the concept that the isolated structure possesses a typical photosynthetic carbon cycle.

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Direct Absorption of Dissolved Strontium-90 and Yttrium-90 by Tadpoles of *Rana temporaria*

THE presence of long-lived radioisotopes, for example strontium-90 and cæsium-137, in fall-out material and their detection in soil, vegetation and animal products have been confirmed[1]. The harmful effects of this build-up of radioisotopes can, to some extent, be predicted by reference to earlier experiences with radioactive materials such as radium. There is very little experimental evidence on the direct biological effects of strontium-90 and cæsium-137. A long-term investigation into the life-cycle of the frog has been started and some exploratory results of the turnover of radiostrontium and radioyttrium by the tadpoles of *Rana temporaria* are of interest.

Tadpoles, in batches of 100, from local ponds, estimated to be 5–7 weeks old, were treated with small amounts of strontium-90, about 0·125 μc. in 500 ml. water containing 100 tadpoles, giving $2 \cdot 5 \times 10^5$ disintegrations/min. strontium-90 and yttrium-90. The experiments were conducted in glass tanks ; the exchange of activity by the glass was shown to be small. The water was tested for radioactivity at intervals. The tadpoles were eventually removed from the water, which was filtered through a sintered crucible to collect the insoluble matter, mainly fæces. The fæces were dissolved in hot nitric acid, which was then suitably diluted. A sample of 10 tadpoles was washed, incinerated, extracted with aqua regia and suitably diluted. The tank contents were, therefore, divided into : (1) water ; (2) fæces solution ; (3) tadpole solution.

The activities of all three solutions were measured at further intervals of time using a type *M*6 Geiger–Müller liquid counter and associated *IDL* counting equipment (scaler, probe unit, and extra-high tension unit). The performance of the counting equipment was checked throughout by means of a standard uranium solution. The background was also checked and found to be practically constant at 13 c.p.m. Five

Table 1

Sample	Strontium-90 (c.p.m.)		Yttrium-90 (c.p.m.)		Strontium-90/yttrium-90 at 175 hr.	
	0 hr.	175 hr.	0 hr.	175 hr.	From liquid counts	From solid source absorption plot
Water	34,000 (*A*)	28,000 (*C*)	34,000 (*A*)	9,500 (*B*)	3·0	3·1
Tadpoles	—	6,000 (*E*)	—	19,300 (*D*)	0·31	0·32
Excreta	—	1,500 (*G*)	—	4,000 (*F*)	0·38	—
Totals	34,000	35,500	34,000	32,800	—	—

experiments as above have been carried out to date, and a typical set of results is represented in Fig. 1.

The decay scheme is as follows :

$$^{90}\text{Sr} \xrightarrow[\substack{0\cdot61\text{ MeV.}\\ 28\text{ years}}]{\beta} {}^{90}\text{Y} \xrightarrow[\substack{2\cdot25\text{ MeV.}\\ 64\text{ hr.}}]{\beta} {}^{90}\text{Zr}$$

It is apparent that the liquid counter is measuring mainly the 2·25 MeV. β-emission of yttrium-90 and very little of the strontium-90 0·61 MeV. β-emission. The glass wall thickness is about 35 mgm./cm.[2] but the effective absolute thickness may be several times this value[2]. The initial drop in curve *AB* is due mainly to absorption of yttrium with some strontium by the tadpoles. The levelling out of *AB* is probably due to the absorption of yttrium as soon as it is formed from the strontium remaining in the solution. After separation of the tadpoles and fæces, the count on the water rises along curve *BC*. This indicates the growth of yttrium in the water from the strontium remaining, until a fresh secular equilibrium is reached at *C*. This value at *C* represents the yttrium now in equilibrium with the strontium not removed by the tadpoles. The counts on the tadpole solution *DE* and the fæces solution *FG* decrease with passage of time to constant levels at *E* and *G*.

Points *C*, *E* and *G*, therefore, represent the amounts of strontium-90 in the water, tadpoles and the fæces respectively at the time of separation, that is, 175 hr. Points *D*, *B* and *F* represent mainly the yttrium-90 content of the three solutions at separation.

Thus, the tadpoles have a strontium-90/yttrium-90 ratio at separation of 6,000/19,000 or 1/3·1. An absorption plot was carried out on an aliquot of the tadpole solution evaporated to dryness on a planchette and almost the same strontium/yttrium ratio was obtained. All the results are summarized in Table 1.

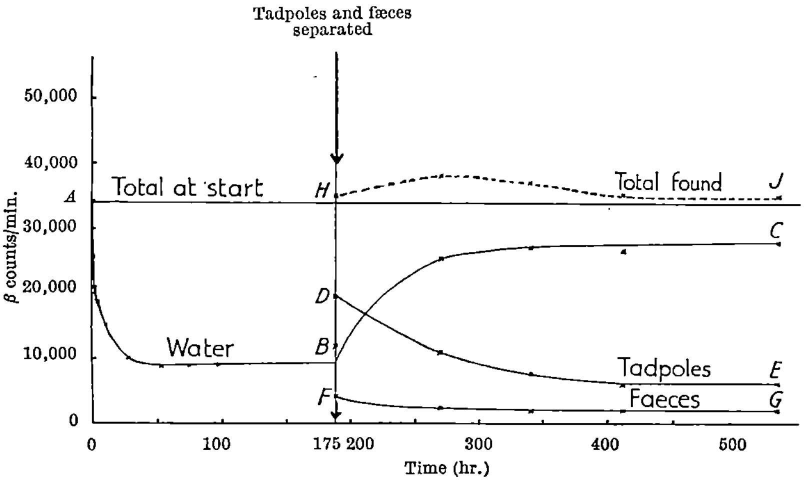

Fig. 1

The 100 tadpoles absorbed in about one week approximately 18 per cent (~0·02 μc.) of the strontium-90 and about 72 per cent (~0·09 μc.) of the yttrium-90.

Attempts were made to wash the strontium-90 from the tadpoles with water, but, even after four weeks, the tadpoles still had a strontium-90 content not appreciably lower than indicated by point *E* (Fig. 1). Ethylenediamine tetraacetic acid (0·01 per cent) solution increased the rate of decontamination. Preliminary investigations indicate that calcium bicarbonate added to the tank results in a lower uptake of strontium-90 by the tadpoles, although the curves obtained are similar to those for soft water. Histological changes and the effect on metamorphosis are being investigated.

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Phagocytosis and the Antigenic Structure of Bacteria

Phagocytosis is one of the mechanisms underlying immunity against infection. In spite of numerous investigations, our knowledge concerning this mechanism is still inadequate. No systematic studies have been conducted on the significance of the antigenic structure of bacteria in the process of phagocytosis, and the data on substances contained in the blood serum promoting phagocytosis and referred to as opsonins or tropins are also inadequate.

The present experiments aimed at elucidating the importance of antigenic structure of bacteria in the phagocytosis process in the case of Gram-negative intestinal bacilli with known antigenic structures.

Horse sera from healthy, non-immunized horses were used in all experiments. These sera were inactivated on the day of experiment for 30 min. at a temperature of 56° C. in order to exclude the participation of the complement, and were used in an undiluted state.

Leucocytes from horse blood were obtained by centrifugation of mechanically defibrinated blood ; they were washed five or six times by centrifuging

Table 1. PHAGOCYTOSIS OF BACTERIA WITH *K* ANTIGENS

Antigen	Strain	Heat susceptibility of antigen	Kind of suspension				Control
			f	60° C.	100° C.	120°C.	
Vi	*S. typhi* *S*–6 *Vi*+	60° C.	0	0	4·0	>40	0
	O 901 *Vi*−		1·55	13·75	>40	>40	0
M	*S. paratyphi B*	100° C.	9·51	1·71	>40	>40	0
L	Alkalescens–Dispar *O*1 *L*+	60–100° C.	0	22·96	>40	>40	0
	L−		>40	>40	>40	>40	0
B	*S. dysenteriae* 2 (*S. schmitzii*)	100° C.	0·54	0·80	>40	>40	0
A	Alkalescens–Dispar *O*6 *A*+	120° C.	0·55	1·60	7·65	>40	0
	A−		5·32	>40	>40	>40	0

with physiological saline at the speed of 2,000 r.p.m. The leucocytes were used for experiments 3–4 hr. after the blood had been taken.

The strains used for experiments were : *Salmonella, Shigella, Alkalescens-Dispar, Escherichia* and *Brucella*. The bacterial suspensions were washed with physiological saline to remove any soluble antigens which might affect the results of the phagocytic reaction. The suspensions to be examined were checked for the presence or lack of the *K, O* and *R* antigens.

The phagocytic reaction was performed by the tube method ; one volume of washed leucocytes was mixed with one volume of inactivated undiluted serum and with one volume of the suspension of the bacterial strain under examination. After rough mixing, the tubes were placed in a water-bath at 37° C. for 20 min. (In control tests physiological saline was used instead of horse serum ; the time of phagocytosis was prolonged to 60 min.) After drying in air, the preparations were fixed by passing them three times over a flame and then for 20 min. in methyl alcohol. The preparations were then stained with undiluted Manson dye by immersion for 3–5 sec. ; afterwards they were thoroughly washed and dried in air.

Counts were made using an oil-immersion objective. The phagocytic index was calculated by dividing the number of bacteria digested by 100 leucocytes by 100. In view of the difficulty of counting bacteria when their number exceeded 40, the actual index above 40 was assumed, not calculated.

To minimize the possibility of side-effects, the suspensions were prepared in a separate room, and the persons reading the results (invariably the same) did not know what bacteria had been used in any given investigation.

The tabulated results present the mean values from six experiments. It is to be stressed that no pronounced differences could be found between particular sera.

The results summarized in Tables 1–3 point to a close relation between the antigenic structure of bacteria and the degree of phagocytosis in the presence of normal, inactivated and undiluted horse serum.

Pronounced differences were found in the phagocytosis of smooth (*S*) and rough (*R*) forms as well as in the phagocytosis of *S*-forms depending on their antigenic structure. These differences were to be seen both with the use of naturally dissociated forms and with suspensions in which some antigens had been destroyed by heating at temperatures of 60°–120° C.

It is of interest that there is complete agreement between the results obtained in the phagocytic reaction and those by serological methods, used as a matter of routine in the experiments on the antigenic structure (agglutination, absorption tests).

The results contained in Table 1 point to the great importance of the surface antigens (*Vi, M, L, B, A*) for the phagocytosis of bacteria which possess them. *K* antigens exert a pronounced inhibitory effect on phagocytosis. A clear-cut relation could be established between heat susceptibility and the extent of phagocytosis.

Table 2. PHAGOCYTOSIS OF BACTERIA WITHOUT *K* ANTIGENS

Antigen	Strain	Heat susceptibility of antigen	Kind of suspension				Control
			f	60° C.	100° C.	120° C.	
—	*S. flexneri X*	—	4·61	>40	>40	>40	0
—	*S. flexneri Y*	—	10·20	>40	>40	>40	0
I	*S. flexneri* 1*b*	—	0·78	1·83	>40	>40	0
III	*S. flexneri* 3	—	0·46	4·38	>40	>40	0
alpha	*DRL* 358/55	100° C.	0	1·90	>40	>40	0
beta	*E. coli* C_3	100° C.	1·92	4·32	>40	>40	0
1*F*	*S. flexneri* 6	120° C.	0	2·75	37·50	>40	0

The results in Table 2 suggest the possibility of differentiating the bacteria in which no *K* antigen could be found (*O* forms). Here, too, differences in the degree of phagocytosis were observed depending on the heat susceptibility and the character of antigen (the presence of thermolabile α-, β-, 1*F* antigens ; the presence or lack of type antigens).

The results in Table 3 suggest the possibility of differentiation between the smooth (*S*) and rough (*R*) form and the detection of the transitional *SR* forms. It was found that *R* forms are also phagocytized in the absence of serum ; this fact distinguishes them from *S* forms, which undergo no phagocytosis in these conditions.

The results presented indicate the great importance of the structure of the bacterial cell in the phagocytic process. They also suggest new possibilities of studies

Table 3. PHAGOCYTOSIS OF SMOOTH (*S*), ROUGH (*R*) AND TRANSITIONAL *SR* FORMS

Strain	Form	Kind of suspension				
		f	60° C.	100° C.	120° C.	
S. sonnei 9773	1st phase	0·93	1·80	3·80	>40	
		0	0	0	0	Control
S. sonnei 3 *H*	2nd phase	21·20	30·50	>40	>40	
		0	0	>40	>40	Control
S. sonnei 4 *H*	2nd phase	28·16	>40	>40	>40	
		0	1·0	>40	>40	Control
S. sonnei 9774	*R*	>40	>40	>40	>40	
		15·0	25·0	>40	>40	Control
Br. abortus	*S*	0	0	2·55	3·03	
		0	0	0	0	Control
Br. abortus	*R*	0	>40	>40	>40	
		0	>40	>40	>40	Control
S. typhi (Bhatnagar)	*R Vi*+	6·18	15·90	28·03	>40	
		0	0	5·60	>40	Control

on the antigenic structure of bacteria by the application of the phagocytic reaction.

The experiments shed some light on the efficiency of the mechanism of phagocytosis depending on the character of infecting bacteria. They also suggest the importance of an as yet unknown factor, contained in the normal horse serum, for the phagocytic process of smooth bacterial forms.

The phagocytic test proved to be more sensitive than serological reactions in the detection of differences in the antigenic structure of bacteria (for example, in the detection of transitional forms).

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Longevity of *Proteus* Group of Amœbæ

Explanation (1) of the findings described by Muggleton and Danielli[1] appears to fit in best with the facts enumerated below.

The normal life-cycle of the *Proteus* group of amoebae consists of four well marked stages: (*a*) spore, (*b*) developing juvenile, (*c*) adolescent, (*d*) mature to senile. It is the adolescent and young adult that can be made to reproduce indefinitely by binary fission. As soon, however, as a rigid control of their environment is relaxed, they proceed with their life-cycle. Chromidia from the nucleus escape into the cytoplasm and develop into spores. When the individual becomes filled with spores it dies. If, however, these spore-filled individuals are placed in a Petri dish and killed by a change in *p*H, the hatching of the spores, and their subsequent development, given a suitable pabulum, can be observed. It has been shown why this development is slow[2]. I am at present engaged in trying to accelerate this growth, and am glad to record here the gift of supplies of bacteria and lettuce-water sent to me by Dr. Muriel Robertson of the Lister Institute.

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Growth and Maturity of the Barnacles *Lepas hillii* and *Lepas anatifera*

Information on the rate of growth of all species of *Lepas* is scanty. Stanley Kemp, in a letter to J. F. Anton[1], quotes three sources, the first of which, referring to an unspecified *Lepas*, gives an increase in capitulum length of about 1 mm. a day; the second and third, referring to *L. anserifera*, give increases of 8 mm. in 8 days, 21 mm. in 40 days and 25 mm. in 107 days. In all cases these are minimum rates since they refer to ships and to a buoy known to be free of barnacles at one date and supporting barnacles of quoted size at another, the moment of settling being unknown.

During the voyage of the yacht *Petula* from Dakar to Barbados in the winter of 1953–54 [2], colonies of barnacles settled on the ship's side above her anti-fouling paint and flourished there throughout the passage. While the ship lay in Dakar harbour preparing for sea, the stores which were loaded into her so increased her draught that some of her white topside paint was submerged, and here many fouling organisms were able to gain a hold. So long as the ship was at anchor only the sessile barnacle *Balanus amphitrite* Darw. was present, but at sea this species largely died off and was replaced by the pedunculate barnacles *Lepas hillii* Leach, *Lepas anatifera* L. and *Conchoderma virgatum* (Spengler). *Conchoderma virgatum* was present in large numbers and early attained a capitulum length of 9 mm. but beyond this length it did not grow, being heavily preyed upon by the trigger fish *Canthidermis maculatus* and *C. sobaco*.

In position 15° N., 31° W., after the ship had been at sea for 30 days, a sample of twenty of the largest *Lepas* growing on the topside was taken and preserved. A further sample of sixty of the largest specimens from an adjacent position was taken after 60 days, in position 15° N., 46° W.

Measurement of the preserved material yielded results summarized in Table 1. The measurements, to the nearest 0·5 mm., were made from the umbo (basioccludent angle) of the scutum to the upper (occludent) tip of the tergum. This dimension may be approximately equated with the capitulum length generally quoted in the literature, being very slightly greater; it is to be preferred to the capitulum length as giving a firmer standard of size.

Table 1. Length Distribution of *Lepas* taken 30 and 60 Days Out

Length (mm.)		11–13·5	14–16·5	17–19·5	20–23
30 days	Total *L. hillii*	3	4	2	0
	Gravid *L. hillii*	0	1	0	0
	Total *L. anatifera*	5	6	0	0
	Gravid *L. anatifera*	0	2	0	0
60 days	Total *L. hillii*	6	10	20	21
	Gravid *L. hillii*	0	2	16	11
	Total *L. anatifera*	0	0	1	2
	Gravid *L. anatifera*	0	0	0	1

The age of the barnacles in the samples is again not known with certainty since settlement on the ship's side was not observed. Colonies containing both species of *Lepas* were established 10 days out, with capitula of perhaps 5 mm., and from the first day out the ship passed among much flotsam bearing mature *L. anatifera* from which infection by this species could have occurred. No *L. hillii* were found on collected flotsam, yet it is certain that both species were well established on the tenth day and it is not unreasonable to suppose that settlement of both began very near to the start of the voyage.

All specimens were opened and searched for embryos. From Table 1 the following may be noted.

(*a*) Among the 30-day group only one specimen of *L. anatifera* among eleven and one of *L. hillii* among nine bore embryos in the ovigerous lamellæ. It therefore seems probable that both species require more than 30 days on average from settlement to maturity.

(*b*) Of the 60-day group of *L. antifera* one out of three bore embryos. Twenty-nine out of fifty-seven *L. hillii* bore embryos, all except two of the gravid examples being longer than 16·5 mm. So large a proportion of the barnacles between 17 and 19·5 cm.

contained embryos that it is probable that this span represents first maturity. Since *L. hilli* achieved, in general, a length of 13–17 mm. in 30 days, 17–19·5 mm. at maturity and 17–21 mm. in 60 days it might be crudely assumed, given a constant increase in length during the second month, that maturity was achieved, on average, in the last two weeks of the second month. Comparing lengths at 30 and 60 days, however, it is seen that the average daily increase of about 0·5 mm. in the first month is not maintained in the second. This check in growth was no doubt due to the attainment of maturity at 17–19·5 mm. It would therefore seem more probable that the growth-rate of 0·5 mm. a day observed in the first month continued to maturity, which on these terms occurred in general on the thirtieth to forty-third day. Thereafter, a growth-rate near 0·03 mm. a day is indicated.

Throughout the voyage the sea temperature was high, ranging from 24·2° to 26·1° C. The conclusions advanced above concerning both growth-rate and the length of the juvenile phase must consequently be applied with caution to animals taken in cooler waters.

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Occurrence of Forms of *Fucus distichus* L. emend. Powell on North Rona and Sula Sgeir

Fucus distichus L. emend. Powell is an extremely polymorphic alga, widely distributed principally on arctic and sub-arctic coasts, and I have recently proposed[1] the recognition of four principal subspecies of this plant. Two of the subspecies—subsp. *edentatus* (De la Pyl.) Powell (a large plant of sheltered shores), and subsp. *anceps* (Harv. et Ward ex Carruthers) Powell (a small plant of exposed shores)—have southern limits in northern and western parts of Scotland and Ireland[2], and are the rarest fucoids in Britain.

As a member of the Glasgow University North Rona Expedition (June 23–July 23, 1958)[3], I have recently been able to investigate the botany and littoral ecology of the small, remote Scottish islands of North Rona and Sula Sgeir which lie about 45 miles north-west of Cape Wrath. Subsp. *anceps* was found on both islands, in small quantity but at several sites in each case, at its usual high level on shores exposed to severe swell and wave action. Subsp. *edentatus* was found on North Rona only, in the moderately sheltered inner parts of two narrow geos facing north and north-east respectively, in the north-eastern part of the peninsula of Fianuis. In the north-facing geo, only a few young (non-fertile) plants were found on large mid-littoral boulders; but in the north-east-facing geo, subsp. *edentatus* formed a distinct belt (of varying depth) in the upper half of the mid-littoral zone, along about 25 m. of shore each side of the geo, and both young (non-fertile) and older (fully fertile) plants were present. The largest plant was 42 cm. in length. Several plants of both sub-species have been examined in detail; caecostomata[1] were present in all, and the conceptacles were hermaphrodite. The only other fucoid found was *F. spiralis* L. (mostly f. *nana*)—very scarce on North Rona only.

The present findings confirm previous observations[2] that subsp. *anceps* can survive more severe exposure conditions than any other fucoid in northern Britain; and these records from such small and isolated islands strengthen my belief[2] that subsp. *anceps* is a relict plant in Britain, a survivor from a period when the climate here was colder.

Subsp. *edentatus* has been reported previously from only three localities in Britain (in the harbours of Lerwick and Scalloway in the Shetland Isles, and in the North Haven on Fair Isle)[2]; the North Rona records therefore establish a new southern limit for the plant on the British side of the North Sea. I have suggested elsewhere[2] that subsp. *edentatus* may have been introduced to the Shetland and Fair Isle localities within recent centuries, perhaps by fishing boats; but it seems scarcely likely that it could have been introduced to North Rona in this way, even though we saw as many as four Norwegian fishing boats at a time anchored close inshore there during periods of rough weather. The possibility of introduction by floating plants cannot be ruled out, of course, but this seems not very likely in view of the prevailing winds and currents. There remains the possibility that subsp. *edentatus* has been present on North Rona, and perhaps at the other three Scottish localities, a very long time—a relict plant, as subsp. *anceps* appears to be; I now much incline to this view.

A detailed report on the littoral flora and fauna of North Rona and Sula Sgeir is being written in collaboration with my colleague Mr. T. B. Bagenal, and will be published elsewhere.

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Selection of Cell Lines in Tissue Culture by the Use of Cytotoxic Antisera

THE cytotoxic action of antisera against nucleoproteins isolated from HeLa, H.Ep. No. 1 and MCN cells has been previously reported from this laboratory[1,2]. Of particular significance was the observation that only cell lines exhibiting epithelial-like morphology (Ep. L) were destroyed by the HeLa and H.Ep. No. 1 antisera, while cells with fibroblast-like morphology (Fb. L) were affected only by the MCN antisera. Consistently, cultures of susceptible cells were completely destroyed by a 1 : 50 dilution of cytotoxic antisera in the presence of guinea pig complement. During the course of these investigations, an established strain of human amnion cells was encountered the behaviour of which toward HeLa and MCN antisera was different from that of cell lines previously examined. A fraction of the cell population was resistant to the MCN antiserum and a fraction was resistant to the HeLa antiserum, even when the antisera were employed at 1 : 4 dilution. It is the purpose of this communication to report the selection of two cell lines from the human amnion strain. These two sublines can be distinguished on the basis of their morphological characteristics, their capacity to support virus multiplication, and their sensitivity to the HeLa and MCN antisera.

The human amnion strain was obtained through the kindness of Dr. L. Hayflick from the Tissue Culture Laboratory of the University of Texas, Galveston, Texas. The establishment and development of this cell strain have been described recently by Fernandes[3]. From its initial isolation, this strain has exhibited epithelial-like characteristics. It has not undergone any of the changes often associated with the development of an established cell line from a primary culture[4]. The cell supported with evident cytopathogenic changes the growth of a number of viruses, including types I, II and III poliomyelitis[3].

The human amnion strain was received in this laboratory on January 21, 1958. It was observed that the cells grew vigorously, although their general growth pattern was not typical of that associated with epithelial-like elements. The cells were mainly of the fusiform type. During initial experiments with poliomyelitis virus, no obvious cytopathology could be ascertained. The cells were tested for their susceptibility to the HeLa and MCN nucleoprotein antisera by the method described[1,2]. Neither antiserum, even at low dilutions, was capable of destroying all the cells. The HeLa antiserum destroyed a maximum of 10–15 per cent of the cell population while the MCN antiserum destroyed at most 85–90 per cent of the cells. Identical results were obtained with undiluted antisera and with antisera diluted 1 : 10, indicating that over this range the percentage of cells destroyed by the antisera was not a function of the concentration of cytotoxic antibodies. Attempts were then made to isolate the two types of cells by means of selective destruction by the two antisera. The procedure followed is described below.

Cells were grown on glass (prescription bottles, 8 oz.) in a medium consisting of 10 per cent horse serum in Eagle's basal medium[5]. They were scraped from the glass wall and suspended in growth medium to give a concentration of 10^6 cells/ml. 2 or 3 ml. aliquots of this suspension were incubated with HeLa or MCN antisera (final dilution 1 : 4) in the presence of guinea pig complement. After 2 hr. the percentage of surviving cells was recorded, the cell suspensions were centrifuged, and the sedimented cells were planted in separate bottles in 90 per cent Eagle's medium and 10 per cent horse serum.

In a successful experiment, growth was observed after treatment with the antisera. Cells that had survived the MCN antiserum treatment grew as separate colonies, each cell having polyhedral contours and large areas of contact with its neighbours. These characteristics were recognizable as epithelial (Ep. L). In contrast, those cells that had survived HeLa antiserum treatment were mostly fusiform with filamentous processes and had no tendency to form separate colonies. This morphology and growth pattern are associated with fibroblasts (Fb. L). Cells of the first type (Ep. L) were completely destroyed by the HeLa antiserum while MCN antiserum completely destroyed the second (Fb. L) type. The two sublines were then transferred and separately maintained. The isolated human amnion sublines were tested for sensitivity to the three types of poliomyelitis virus. The virus pools employed were cultures of monkey kidney cells infected with the virus agents. The results of titrating these three pools in tubes of the amnion Ep. L and Fb. L lines, as well as the initial titre in the monkey kidney cultures are shown in Table 1. All three types of polio produced cytopathogenic changes in the Ep. L line through 10^{-5}–10^{-6} dilutions of virus, while no cytopathology was observed in the Fb. L line even at the highest virus concentrations. Production of type II polio virus by the two sublines was studied by back titration of infected culture fluids on monkey kidney cells. Ep. L cells were exposed to a 10^{-5} dilution of type II virus ; the medium was harvested and titrated on monkey kidney cells through five serial ten-fold dilutions. A five-log increase in virus concentration was demonstrated in the Ep. L cells. By contrast, when culture fluids from the Fb. L cells were titrated in monkey kidney cultures, no increase in virus concentration could be demonstrated. Several passages of type II polio in the Fb. L cells yielded no virus as could be determined by back titration in monkey kidney.

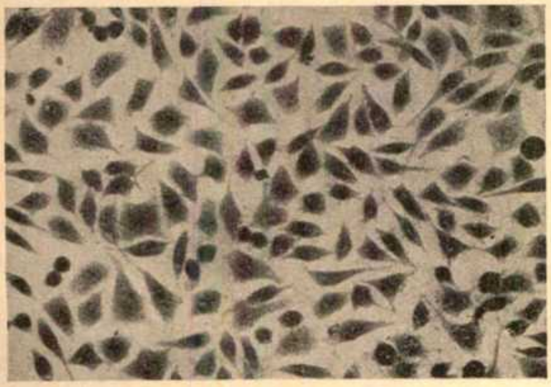
Fig. 1. Human amnion, Fb. L subline. Hæmatoxylin and eosin. (× 160)

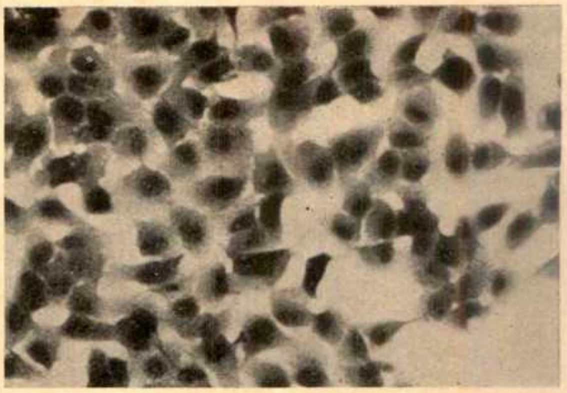
Fig. 2. Human amnion, Ep. L subline. Hæmatoxylin and eosin. (× 160)

During four months of observation, the Fb. L line has remained unchanged, while in the Ep. L line there has been a constant increase in the number of cells sensitive to the MCN antiserum. This tendency has been controlled by periodic treatment of the cells with MCN nucleoprotein antiserum until a stable epithelial line was obtained. In some bottles which have not received this treatment, the MCN antiserum-sensitive cells have increased after four transfers to the level observed in the original culture (85–90 per

Table 1. TITRATION OF TYPES I, II AND III POLIOMYELITIS VIRUS IN MONKEY KIDNEY, AMNION EP. L AND AMNION FB. L CELLS

Virus	*TCD*50/ml.*		
	Monkey kidney	Amnion Ep. L	Amnion Fb. L
Type I, Mahoney	7·0	5·4	†
Type II, MEF,	6·5	5·0	†
Type III, Saukett	6·7	5·8	†

* Expressed as logarithms to the base 10.
† No cytopathology seen at any virus concentration.

cent). This phenomenon probably represents the more rapid proliferation of some fibroblast elements left among the epithelial cells, a possibility which is being studied by cloning techniques. In addition, the number and morphology of the chromosomes, the growth characteristics, and certain biochemical properties of the two cell lines are under investigation.

It is of particular interest that the cellular morphology is significant with respect to virus susceptibility[6,7] and that a cell type with certain specific characteristics can be rapidly selected by the application of antisera to a mixed cell culture.

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Antigenicity and Survival of Cartilage Homografts

DURING the course of investigation of the reasons underlying the ability of cartilage grafts to survive in foreign hosts for long periods, the effects of cartilage homografts and heterografts on the regional lymph node were studied in order to determine whether such grafts were antigenic[1]. The results of this test indicated that both types of graft do evoke an active immune response in the host animal, and it was discovered, further, that heterografts do so even after having been boiled for periods of up to 10 min.[2]. This test does not, however, indicate whether the host animal becomes fully immunized by the foreign cartilage, and in order to determine whether this is so, rabbits bearing cartilage homografts have been challenged with skin homografts from the cartilage donor.

Thirty-six rabbits were used in the investigation. Eighteen control rabbits received a fitted skin homograft of 1½ in. × ½ in. Eighteen experimental animals were given 0·2 gm. of diced homologous cartilage on each of two occasions four days apart, followed by a fitted 1½ in. × ½ in. skin homograft from the cartilage donor on the fourteenth day after the second cartilage implant. A skin homograft of 0·36–0·44 gm. weight will fully immunize an adult rabbit within 14 days[3]. All 36 skin homografts were removed on the sixth day after grafting, and 7μ paraffin sections were stained by hæmatoxylin and eosin. The graft condition was assessed histologically, using the following classification: (*A*) survival, with proliferation, of the entire graft epithelium; (*B*) breakdown of proliferated or still proliferating epithelium in progress; (*C*) breakdown of non-proliferated graft epithelium in progress or complete. 'Immune' type of breakdown.

The results are presented in Table 1. They indicate that, in the majority of cases, implantation of 0·2 gm. of homologous cartilage from the same donor on two occasions is insufficient to elicit a state of transplantation immunity in the host. Only five (28 per cent) of 18 rabbits so grafted appear to have become fully immune.

Table 1

Graft condition	Control animals	Experimental animals
A	8	4
B	10	9
C	0	5

This finding raises the question of whether cartilage homografts survive because of their mild degree of antigenicity. This does not appear to be the case, since further experiments I have carried out show that cartilage homografts can survive in animals fully immunized by skin homografts from the same donor. These findings will be published in greater detail elsewhere. The ability of cartilage homografts to survive may therefore well be attributable to the peculiar physico-chemical character of the matrix, as was first postulated by Bacsich and Wyburn[4]. The matrix would appear to behave after the fashion of the semipermeable diffusion chamber devised by Algire, Weaver and Prehn[5], which allows foreign cells to survive in an immune host.

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A Technique for the Investigation of the Competitive Saprophytic Ability of Soil Fungi by the Use of Easily Decomposed Substrates

THE method commonly used to determine the competitive saprophytic ability of soil fungi consists of exposing suitable substrates to colonization by the fungus in non-sterile soil. A serious disadvantage of this method is that only relatively resistant substrates, for example, wheat straw, can be used effectively because of the manipulation to which the substrate has to be subjected after incubation. Less-resistant substrates such as portions of non-woody roots, rhizomes and cylinders or disks of storage parenchyma of carrots or potatoes, etc., are so softened by the action of soft-rotting organisms in the soil that it becomes difficult to cleanse them adequately of adhering soil, and hence to state with confidence that fungi isolated from them have actually colonized the substrate in competition with the general soil microflora. It is very important to test the suitability of any potential substrate, for, as Garrett[1] has pointed out in the case of root-infecting fungi, one is usually trying to demonstrate a negative character, that is, inability to compete as a soil saprophyte, and to obtain the strongest circumstantial evidence the killed host must be used as the substrate. A substrate such as wheat straw can probably only yield evidence relevant to fungi pathogenic to wheat or at most to cereals;

hence the need to be able to employ any substrate that suggests itself. Since the chief obstacle to the use of soft tissues as substrates is the difficulty of removing the unwanted soil, the present method has been designed to prevent all unnecessary contact with the soil.

The rhizome of *Convolvulus sepium* was the substrate used in the development of this technique. Lengths of rhizome were washed free from soil, blotted dry, wiped with a pad of cotton-wool soaked in 95 per cent alcohol and washed again in tap water. When dry the pieces of rhizome were placed inside 1¼ in. lengths of sterilized glass tube of suitable diameter and trimmed until approximately ⅛ in. of tissue protruded from each end of the tube. A number of tubed substrates were exposed to propylene oxide vapour in a sealed container for 44 hr. Rhizome thus treated yielded no fungi when plated on potato dextrose agar. The sterile tubed substrate was then exposed to colonization by fungi in various soil/inoculum mixtures maintained at a pre-determined moisture content. At the end of the incubation period batches of ten tubed substrates, which had been placed horizontally in the soil, were recovered and treated as follows: The protruding ends were trimmed off and the tubes placed in a 250-ml. beaker. They were washed in a strong jet of water, using about 500 ml. of water in all. The rhizome segments were then removed from the tubes, washed in two changes of tap water, shaken in 50 ml. of 0·1 per cent mercuric chloride in 10 per cent alcohol for 1 min. and finally washed in three 100-ml. portions of sterile streptomycin sulphate solution (51·8 I.U./ml.). The washed substrates were then plated on potato dextrose agar and incubated at 25° C. for 10 days.

Table 1 illustrates the use that is being made of this technique in a study of the ecology of some members of the genus *Cylindrocarpon* Wollenweber. The results were obtained by examining the incubated substrates and the surrounding medium for the characteristic macroconidia of these fungi. An arbitrary method of scoring was used, 10 units being given to each rhizome segment which yielded macroconidia. Some species of *Cylindrocarpon* tend to produce mostly microconidia which are less characteristic of the genus than the macroconidia. Segments bearing only microconidia were therefore disregarded, even though it was extremely likely that the test fungus had colonized the segment. *Fusarium culmorum* was included in the tests for comparative purposes since several workers have shown that this organism possesses a high degree of competitive saprophytic ability.

These results indicate that this technique is sufficiently sensitive to distinguish between the competitive saprophytic ability of members of the same genus. The technique can be adapted in various ways. For example, by cutting the substrate into 2 mm. sections and plating these in known sequence on agar, information can be obtained not only about the ability of a fungus to colonize the substrate in competition with the general soil micro-flora but also about its rate of spread along the substrate.

Table 1. PERCENTAGE COLONIZATION OF RHIZOME SEGMENTS OF *Convolvulus sepium* BY *Cylindrocarpon* spp. AND *Fusarium culmorum* IN A RANGE OF INOCULUM/SOIL MIXTURES

Percentage inoculum/soil	0	2	10	50	90	98	100
F. culmorum	100	100	100	100	100	100	100
C. ehrenbergii	0	0	0	20	100	80	100
C. olidum	0	0	10	30	80	80	100
C. janthothele var. *minor*	0	0	0	0	10	10	100
C. candidum	0	0	0	0	0	10	100
C. obtusisporum	0	0	0	0	0	20	100
C. radicicola	0	10	0	0	10	20	100
C. sp. (T.W.3)	0	0	0	0	0	10	100

We wish to thank Dr. W. L. Gordon of the Plant Pathology Laboratory, Winnipeg, who supplied some of the isolates of *Cylindrocarpon*.

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A Direct Method for Determination of Forward-Mutation Rates in *Neurospora crassa*

THE main difficulty in estimating forward-mutation (from wild type to mutant) rates at specific loci in micro-organisms is the determination of the total number of specific mutations in a given population of cells after mutagenic treatment. In general, mutation rates are so low that the number of specific mutants cannot be readily determined by direct methods. An attempt has been made to determine forward-mutation rates at specific loci[1] by indirect methods, using the 'filtration-concentration' technique, which permits only partial recovery of the induced mutants. Later, an effort was made to determine what proportion of the total mutants induced at each of these loci is recovered with such techniques, by reconstruction experiments in which various mixtures of wild-type and mutant conidia were used. To circumvent the various assumptions that must be made to obtain estimates of the forward-mutation rates from the data obtained by such indirect methods, we developed an experimental technique that permits the estimation of the forward-mutation rates of specific loci by a direct method.

The colonial microconidiating albino (*al*-2) strain, 76–*OR*2–7*A*, gives white spherical colonies with very restricted growth-rates either on solid media in Petri plates or in viscous media in liquid culture. Success of the new method depends on morphological distinction between certain mutants and wild type in such a genetic background. In *ad*-3 mutants, a purple pigment is accumulated in the mycelium that readily distinguishes such mutants from wild type. Moreover, production of this pigment can be enhanced by use of growth-rate-limiting levels of adenine and by incubation at 37° C. Thus intermediate alleles with only partial requirements for adenine can also be recovered. After mutagenic treatment of conidial suspensions of strain 76–*OR*2–7*A*, aliquots were inoculated into 20-l. bottles filled with 12–15 l. of minimal medium supplemented with 1 μgm. of adenine sulphate per ml. and made viscous by the addition of 0·15 per cent agar. In this medium, individual conidia are kept well separated and, instead of clumping together, develop into distinct spherical colonies. The medium is stirred by slow aeration through a 6-mm. glass tubing constricted at the tip. All bottles were incubated at 37° C. When individual colonies had developed into spheres 2–3 mm. in diameter, the contents of each bottle were poured into white enamelled developing trays (40 cm. × 60 cm.) to form thin layers. The purple adenine mutants were recovered on the basis of the characteristic purple

Table 1. The Frequency of X-Ray Induced Forward Mutations at the *ad*-3*A* and *ad*-3*B* Loci

Dose (kr.)	Survival		Total purple mutants	*ad*-3*A* mutants			*ad*-3*B* mutants		
	No. of conidia analysed $\times 10^6$	Percentage of initial		No. found	Mutants per 10^6 viable conidia		No. found	Mutants per 10^6 viable conidia	
					Initial	Surviving		Initial	Surviving
None	7·60	100·0	0	0	—	—	0	—	—
4·5	6·64	87·5	16	3	0·39	0·45	13	1·7	2·0
18	5·12	67·4	26	5	0·66	0·98	21	2·8	4·1
36	2·28	30·0	76	13	1·71	5·70	63	8·3	27·6
72	0·4	5·3	73	14	1·84	35·0	59	7·8	147·5

colour of the mature colonies. The total number of colonies in each bottle was estimated by dilution and plating of an aliquot from the control and treated series.

Since phenotypically indistinguishable *ad*-3 mutants originate by mutation at two separate but closely linked loci[2] (individual mutants can be identified as being *ad*-3*A* or *ad*-3*B* by heterokaryon tests), the mutation rates of two loci can be compared under the same conditions. The system also permits an investigation for specificity of mutagens since a comparison can be made of the proportion of the two types of *ad*-3 mutants after treatment of wild type with various types of mutagenic agents.

In an experiment for determining the rates of forward-mutation after X-ray treatment, aliquots of a conidial suspension were left untreated or irradiated with doses of 4·5, 18, 36 or 72 kr. Survival rates and the total number of purple mutants obtained with each treatment of the five aliquots of conidia are given in Table 1. No mutants were recovered from untreated conidia, and a total of 191 mutants were recovered from the four X-ray treatments. Genotypes of individual purple mutants were determined in subsequent heterokaryon experiments in which *ad*-3*A* and *ad*-3*B* tester strains were used. Since more purple mutants were recovered in this one experiment than in all other forward-mutation experiments combined[3], it was of interest to determine whether all such mutants were restricted to only the two known types: *ad*-3*A* or *ad*-3*B*. Since all the 191 mutants gave a positive heterokaryon test with one tester strain and a negative test with the other, all mutants were either *ad*-3*A* or *ad*-3*B*. No double *ad*-3*A* *ad*-3*B* mutants were recovered and no evidence was obtained for the presence of other loci giving phenotypically purple mutants in either the *ad*-3 region or elsewhere in the chromosome complement. Of the 191 purple mutants, 35 were *ad*-3*A* mutants and 156 *ad*-3*B* mutants.

A comparison of the total numbers of *ad*-3*A* mutants and *ad*-3*B* mutants gives a ratio of 1 : 4·5. This difference in the recovery of the two types of mutants was not unexpected since the combined data from numerous forward-mutation experiments in which the 'filtration-concentration' technique was used indicated an excess of *ad*-3*B* mutants. The present experiment provides direct evidence for a greater sensitivity to mutation as a result of X-irradiation of the *ad*-3*B* locus than the *ad*-3*A* locus. In Table 1, it can be seen that the induced rate of mutation of the *ad*-3*B* locus is about 4–5 times as high as the *ad*-3*A* locus at each dose level tested.

Although a microconidial strain was used in this experiment, the shape of the survival curve was not that expected[4] from a strain with only uninucleate conidia. The data suggest that a portion of the conidia was not uninucleate; thus the mutation rates for each locus were calculated on the basis of mutations per conidium, rather than in terms of mutations per nucleus or chromosome. By extension of the experimental points, maximum forward-mutation rates with this strain expected at a dose of 55 kr. are 9·7 and 2·1 per 10^6 viable conidia treated for the *ad*-3*B* and *ad*-3*A* locus, respectively.

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Some Observations on the Life-Cycle of *Atoxoplasma*, with Particular Reference to the Parasite's Schizogony and its Transmission by the Mite *Dermanyssus gallinae*

Since it was first shown that *Toxoplasma* infections may occur naturally in some birds (notably pigeons and chickens) there has been considerable speculation on the possible role of wild birds as host reservoirs for human *Toxoplasma* infections.

Although there have been many reports of *Toxoplasma* in a wide variety of wild birds, a large number of these observations are due to confusion of this parasite with hæmogregarines, schizonts of hæmogregarines, coccidial merozoites and exoerythrocytic stages of *Plasmodium*. One parasite even more frequently mistaken for *Toxoplasma* is *Atoxoplasma*[1]. This confusion is not surprising, when diagnosis is restricted to observations on the individual organism, for the two parasites are morphologically very similar. Their superficial resemblance to one another, failure to demonstrate any other stages in their life-cycles and the common habitat of both parasites in the cells of the lymphoid–macrophage system of the host have drawn many authors to the conclusion that *Atoxoplasma* and *Toxoplasma* are at least very closely related.

The following preliminary report is a summary of some recent studies of *Atoxoplasma* and clearly indicates that this parasite is much less closely related to *Toxoplasma* than was previously supposed.

The opportunity to study *Atoxoplasma* arose when I found 100 per cent of adult house sparrows (*Passer domesticus domesticus*) examined to be infected: these birds were trapped in the St. Albans area of Hertfordshire.

Later in the year it was established that young sparrows became infected, at an early age, while still in the nests: obviously, then, the mode of transmission was an extremely efficient one.

Large numbers of fledgling sparrows were trapped: all were infected, some very heavily. Many of these birds died in the aviary in which they were main-

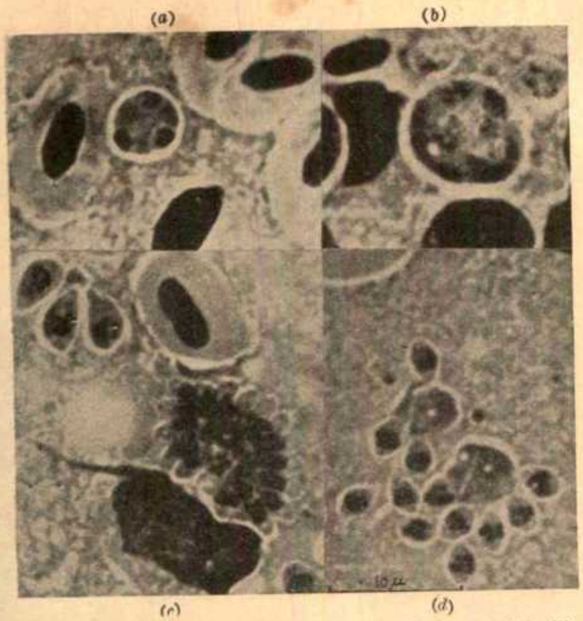

Fig. 1. (*a*) Early schizont of *Atoxoplasma* with three nuclei. (*b*) Schizont with ten nuclei. (*c*) Schizont, nearly mature, showing the peripheral distribution of the nuclei and finger-like protrusions of cytoplasm which form the merozoites. Compare size of merozoites with the normal *Atoxoplasma* seen in top left of same photomicrograph. (*d*) Mature schizont in process of splitting into merozoites; note residual cytoplasm

tained. Post-mortem examination of these birds revealed the spleens to be double their normal volume while the livers were enlarged, pale and frequently marbled in appearance. It was concluded that the tremendous numbers of atoxoplasms were responsible for the deaths.

A study of impression smears of spleen, liver and bone-marrow showed all stages of an undoubted schizogonic process of the parasite (Fig. 1, *a*–*d*). This occurs within the cells of the lymphoid–macrophage system, many of the schizonts becoming dislodged in the preparation of the smears. Up to 20–30 merozoites may be produced: these are substantially smaller than the normal atoxoplasm and possess a much more compact nucleus.

Atoxoplasma was passaged to canaries by the intraperitoneal inoculation of heavily infected, triturated sparrow tissues. Many of the infected canaries died, one with a very intense infection similar to that seen in the sparrows. The possibility of concomitant *Toxoplasma* infections being responsible for the sparrow and canary deaths was ruled out by the inoculation of mice, hamsters and guinea pigs, none of which became infected.

An apparent transmission of *Atoxoplasma* occurred when a canary was placed near another cage containing infected birds. As the only factor to account for this transmission was heavy infestation of the birds with 'red mite' (*Dermanyssus gallinae*) particular attention was focused on this ectoparasite.

Large numbers of mites from infected birds' cages were fed to a newly obtained canary. This bird was killed 14 days later and proved infected.

At present, attempts are being made to determine whether or not any development of *Atoxoplasma* takes place in the mites. So far it has only been possible to show that large numbers of the parasite can be found in crush smears of mites taken after feeding them on infected sparrows, but extended observations are necessary.

It seems likely that *Atoxoplasma* may be transmitted in Nature by mites. This suggestion is supported by the transmissions described above; also by the fact that *Dermanyssus gallinae* is commonly found in the nests of many wild birds (particularly sparrows) and young sparrows invariably become infected before they leave the nests.

The demonstration of a schizogonic phase of *Atoxoplasma* in the vertebrate host and the transmission of the parasite by mites now sharply differentiates *Atoxoplasma* from *Toxoplasma*.

A detailed account of these observations is to be published in the near future.

Added in proof. Since this communication was prepared, a number of naturally infected canaries have been found. Superficially this would appear to invalidate the experimental transmissions. As all canary breeders I have questioned admit to "inevitable presence of red-mite infestations in aviaries at some time or other", this ectoparasite must still remain highly suspect. The naturally infected canaries had been bred in outdoor aviaries, in the close vicinity of nesting sparrows.

R. LAINSON

London School of Hygiene and Tropical Medicine,
London, W.C.1. Sept. 26.

[1] Garnham, P. C. C., *Parasitology*, **40**, 328 (1950).

Perfect and Imperfect Density Dependence in Population Dynamics

IN his recent article[1], Solomon has not made clear either my thesis or his reason for rejecting it. The thesis was developed in relation to my theory of natural control of insect populations for which a new classification of environmental factors was necessary[2,3]. Let me attempt to clarify.

An individual organism fulfils itself when it lives healthily, realizes its reproductive capacity fully, and dies of old age (senescence). Everything which helps or hinders fulfilment of the individual is the effective environment. Starting from Smith's[4] definition of a density-dependent factor, the effective environment may be classified as perfectly and imperfectly density-dependent factors and density-independent factors. There is only one perfectly density-dependent factor, intraspecific competition. The group named imperfectly density-dependent is comprised entirely of enemies (including competing species). Some enemies (for example, browsers, fruit eaters, etc.) come into the density-independent group of factors, a group which is otherwise well known as to its constituents. That is my position[2,3] very briefly.

In conversation and correspondence (October–December 1957) Solomon held, in substance, that since (1) intensity of intraspecific competition can be different for the same population number hence (2) this competition is not affected solely by numbers, that is, is not perfectly density-dependent. I argued that while (1) is correct, (2) is seen to be a *non-sequitur* as soon as it is realized that intraspecific competition is essentially a matter of environmental capacity. When intensity of competition is different for the same population number, this just means that environmental capacity is different. There is no getting away from the fact that for any given environmental capacity intraspecific competition is perfectly density-dependent. If the capacity alters, the curve of competition intensity changes in regard to the level of numbers for its origin and possibly changes in regard to its slope, but it does not cease to be a function solely of numbers. It should be added that alteration of environmental capacity can be absolute, that is, independent of the organisms concerned, as when weather favours or retards the growth of vegetation for food or shelter; or it can be relative, that is, due to modification of average individual needs brought about, for example, by weather increasing and decreasing activity, or by some change in age-distribution or genetical composition of the population[3]. Mr. Solomon did not counter the above argument to my satisfaction.

Solomon now says[1]: "I do not believe that *factors* perfectly dependent on density exist except at a high level of abstraction. In Nature, the actions of all factors are presumably variable and inexact." [The italics are mine.]

In that statement it is interesting to note (1) a plurality not present in my thesis (cp. "factors"); and (2) an indirect admission that I am correct in holding enemies to be at best imperfectly density-dependent factors. I would suggest also that the "high level of abstraction" has actually existed for a long time in the unwitting ascription of perfect density-dependence to enemy action as in Nicholson's popular theory of natural control of population.

It is also interesting to note Solomon's adherence to another abstraction, namely, the 'inverse' density-dependent factor. This factor was a tentative proposition by Howard and Fiske[5], of which, as Allee *et al.*[6] point out, Smith[4] "made little". The proposition is on a par with the erroneous idea prevailing until recently[2,3] that a density-independent factor killed a constant proportion of the population in Nature. I put it to Mr. Solomon that there is no field evidence of 'inverse' density-dependence which will stand up to stringent ecological and statistical analysis (and that includes so-called 'sexual isolation').

Again there seems to me little point in distinguishing between factors the density-dependent action of which is (1) immediate ('direct') or (2) delayed ('alternate') simply because enemy reproduction is not immediate. I think it more useful to regard delay in action as contributing to the imperfection I ascribe to the density-dependence of enemies.

I should go further than Varley[7] (though for different reasons) and say there is no advantage in adopting Solomon's classification of density-dependent factors.

A. Milne

Agricultural Research Council
Unit of Insect Physiology,
24 Leazes Terrace,
Newcastle upon Tyne 1. July 23.

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[1] Solomon, M. E., *Nature*, **181**, 1778 (1958).

[2] Milne, A., *Canad. Entom.*, **89**, 194 (1957).

[3] Milne, A., *Cold Spring Harbor Symposia on Quantitative Biology*, **22**, 253 (1957).

[4] Smith, H. S., *J. Econ. Entom.*, **28**, 873 (1935).

[5] Howard, L. O., and Fiske, W. F., *Bull. U.S. Bur. Ent.*, No. 91 (1911).

[6] Allee, W. C., Emerson, A. E., Park, O., Park, T., and Schmidt, K. P., "Principles of Animal Ecology", 331 (Saunders, Philadelphia and London, 1949).

[7] Varley, G. C., *Nature*, **181**, 1780 (1958).

I OBJECTED to Dr. Milne's proposed term "perfectly density-dependent" because neither intraspecific competition nor any other factor to be observed in the field is likely to preserve (in the words of his definition[1]) "an exact linear (or curvilinear) relationship between increasing action of the factor and increasing density of the species". The logic of his argument can be made clearer by re-stating it as follows. If all causes of variation were removed, there would be a simple and exactly maintained relationship between the intensity of intraspecific competition and the population density. Let us relegate all sources of variation to a category for which we shall borrow the term environmental capacity. Then we are left with a perfectly density-dependent factor, intraspecific competition.

I see no objection to this argument as an exercise in logic or as a step in the development of a simplified mathematical theory. I only wish to point out that the perfection achieved in this way bears little relationship to what we can expect to find in studying the dynamics of actual populations, and that therefore the term seems inappropriate for use by the practical ecologist. It should perhaps be added that, by a similar process of abstraction, the relationships expected to hold between a parasite or predator population and the density of its host can also be made to appear simple and regular, as in the mathematical theories, although imperfect in Milne's sense.

Milne's remark about Nicholson's theory refers to a point already dealt with by Varley[2] in these columns.

Milne objects to the idea of inverse factors because "there is no field evidence of 'inverse' density-dependence which will stand up to stringent ecological and statistical analysis". But since, unfortunately, we have very little field information of this quality on density relationships of any sort, we can scarcely attach special significance to the lack of it in this case.

As to "the erroneous idea prevailing until recently that a density-independent factor killed a constant proportion of the population in Nature", in fact the idea that the action of density-independent factors varies in intensity is, of course, neither new nor at all unfamiliar. It is true that Howard and Fiske[3] wrote of catastrophic factors that "the average percentage of destruction remains the same, no matter how abundant or how near to extinction the insect may have become", and Smith[4], in re-naming these factors 'density-independent', described them as "destroying a constant percentage regardless of the abundance of the insect". But it seems obvious that their intention was to argue that the percentage effect of density-independent factors did not vary in response to changes in population density, not that they necessarily produced a mortality-rate which did not vary in time. In a discussion[5] published nine years ago, I unhesitatingly adopted the former view, and have seen no protest on this score. Milne's claim implies that ecologists have hitherto believed that mortality due to weather factors is constant.

Although Milne sees no advantage in my proposed classification of density-relationships, some ecologists may do so. It has at least the advantage of making no assumptions about particular types of factors in advance of our knowledge of them. This discipline is likely to be valuable for some time to come, even if the categories I suggested are augmented, subdivided or replaced by others.

M. E. Solomon

Pest Infestation Laboratory,
Department of Scientific and Industrial Research,
Slough, Bucks. Aug. 30.

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[1] Milne, A., *Canad. Entom.*, **89**, 193 (1957).

[2] Varley, G. C., *Nature*, **181**, 1780 (1958).

[3] Howard, L. O., and Fiske, W. F., *Bull. U.S. Bur. Ent.*, No. 91 (1911).

[4] Smith, H. S., *J. Econ. Entom.*, **28**, 873 (1935).

[5] Solomon, M. E., *J. Anim. Ecol.*, **18**, 1 (1949).

[This correspondence is now closed.—Editors, *Nature*.]

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, November 3

University of London (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Dr. J. R. Postgate: "The Sulphur Bacteria".* (Further lecture on November 10.)

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. A. F. Fox: "Some Problems of Petroleum Geology in Kuwait".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5.30 p.m.—"African Safari" (colour film with commentary by Lewis Cotlow).

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Capt. G. S. Ritchie, D.S.C., R.N.: "Hydrography".

Royal Institute of Chemistry, London Section (at Norwood Technical College, Knight's Hill, West Norwood, London, S.E.27), at 7 p.m.—Dr. J. F. Padday: "The Use of Photography in Scientific Investigations".

Tuesday, November 4

University of London (at Birkbeck College, Malet Street, London, W.C.1), at 4 p.m.—Dr. E. W. Gorter (Eindhoven): "The Orientation of the Magnetic Moments in Ferrimagnetic Oxides with Respect to Each Other and to the Crystal Axes".*

University of London (at the London School of Economics and Political Science, Houghton Street, London, W.C.2), at 5 p.m.—Prof. W. F. Wertheim (Amsterdam): "Sociological Aspects of Inter-island Migration in Indonesia".*

University of London (at Bedford College, Regent's Park, London, N.W.1), at 5.15 p.m.—Prof. H. G. Eggleston: "The Concept of Convexity"* (Inaugural Lecture).

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. R. C. M. Barnes and Dr. J. H. Stephen: "Operating Experience with a Transistor Digital Computer"; Mr. D. Eldridge: "A New High-Speed Digital Technique for Computer Use".

University of London (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. J. F. Coales: "Automatic Control".* (Further lectures on November 6, 11 and 13.)

University of London (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. J. F. Danielli, F.R.S.: "A Generalized Cell Theory and Its Relevance to Certain Problems of Drug Action".* (Further lectures on November 11 and 18.)

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. W. N. Neat: "The Spectre Rocket Engine".

Wednesday, November 5

University of London (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. G. M. McGowan: "Potassium Metabolism".*

Physical Society, Colour Group (in the Lecture Theatre, Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Mr. F. S. Said: "The Transmissivity of the Living Human Crystalline Lens". 5 p.m.—Films: "This is Color" and "Color Magic".

Society for Analytical Chemistry (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 7.45 p.m.—Dr. B. J. Mason: "Recent Developments in the Physics of Rain and Rainmaking".

Thursday, November 6

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. D. Wilkie: "The Aims of Sexual Reproduction".*

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. J. Needham, F.R.S.: "The Missing Link in Horological History—a Chinese Contribution" (The Wilkins Lecture).

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. John Ramsbottom, O.B.E.: "Linnaeus, *Pan Suecica* and Nomenclature"; Dr. H. Hamshaw Thomas, M.B.E., F.R.S.: "Angiosperm Evolution—Historical and Ecological Considerations".

Institute of Refrigeration (at the Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Sir Rupert de la Bère, Bart., K.C.V.O.: Presidential Address.

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. T. S. Pick and Mr. A. Readman: "The Recognition of Moving Vehicles by Electronic Means".

Royal Anthropological Institute of Great Britain and Ireland (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Miss Kathleen M. Kenyon, C.B.E.: "Some Observations on the Beginnings of Settlement in the Near East".

University of London (at Queen Elizabeth College, Campden Hill Road, London, W.8), at 5.30 p.m.—Sir Vivian Fuchs: "The Trans-Antarctic Expedition".

Institution of Mechanical Engineers, Internal Combustion Engine Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Do We Know Enough About the Induction and Exhaust Processes?"

Society of Chemical Industry, Microbiology Group (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Dr. Herchel Smith: "Investigations of the Biosynthesis of some Mould Metabolites using Radioactive Tracers".

Institute of Metals (at the Royal School of Mines, South Kensington, London, S.W.7), at 7 p.m.—Prof. J. G. Ball: "Experimental Features of Investigations with Radioactive Materials".

Polarographic Society (at "The Duke of York", 8 Dering Street, London, W.1), at 7 p.m.—Informal Discussion Meeting on "Some Problems Encountered in the Polarography of Metallic Cations in the Presence of Bis-Quaternary Compounds" introduced by Dr. P. O. Kane.

Royal Institute of Chemistry, London Section (joint meeting with the Brunel College of Technology Chemical Society, at the Brunel College of Technology, Woodlands Avenue, Acton, London, W.3), at 7 p.m.—Prof. D. P. Craig: "Theory and Experiment in Chemistry".

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Sir Eric Rideal, F.R.S.: Irving Langmuir Memorial Lecture.

Thursday, November 6—Friday, November 7

Institute of Welding (at 54 Princes Gate, Exhibition Road, South Kensington, London, S.W.7), at 10 a.m. daily—Autumn Meeting.

Friday, November 7

Mineralogical Society, Clay Minerals Group (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 10.45 a.m.—Scientific Papers. 5 p.m.—Annual General Meeting.

Association of Applied Biologists (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, London, S.W.7), at 10.50 a.m.—Symposium on "Clubroot Disease".

Council for the Preservation of Rural Wales (at the Church House, Welshpool, Montgomeryshire), at 2.30 p.m.—Annual General Meeting. Speakers: The Lady Megan Lloyd George, LL.D., J.P., M.P., the Rt. Hon. Clement Davies, P.C., Q.C., M.P.

Royal Society of Medicine, Anæsthetics Section (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Prof. J. H. Burn: "The Pharmacological Investigation of Anæsthetic Drugs for Clinical Trial".

Institution of Electrical Engineers, Medical Electronics Discussion Group (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion Meeting on "Problems in the Measurement of Blood Flow". Opening Speakers: Dr. A. C. Dornhorst and Dr. D. A. McDonald.

Society of Dyers and Colourists, London Section (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Mr. S. M. Jaeckel and Mr. D. L. Munden: "Some Aspects of the Dyeing and Finishing of Fabrics Knitted from Bulky and Stretched Yarns".

Society of Chemical Industry, Fine Chemicals Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. A. Cohen: "Synthesis in the Ergot Alkaloid Field".

Royal Aeronautical Society (joint meeting with the Helicopter Association, at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. G. S. Hislop: "Development of the Fairey Rotodyne".

Saturday, November 8

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Prof. C. von Fürer Haimendorf: "Buddhist Society in the Himalayas".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant (with special qualifications in organic chemistry) in the Department of Chemistry—The Secretary, The University, Edinburgh (November 8).

Head (with a good honours degree and experience of teaching in an institution of higher education) of the Department of Science, Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (November 10).

Lecturer in Radio-Astronomy—The Registrar, The University, Manchester 13 (November 10).

Senior Lecturer (with a good honours degree and teaching experience) in Applied Mathematics; and Lecturers (2) (with a good honours degree and teaching experience) in Mathematics at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (November 10).

Assistant Lecturer in the Department of Pure Mathematics—The Registrar, University College of Wales, Aberystwyth (November 15).

Assistant Lecturer (with an honours degree from a recognized university and preferably previous teaching or research experience) **in Psychology** at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 15).

Leverhulme Student (with a postgraduate diploma in chemical engineering or equivalent qualifications) **in Chemical Engineering**—The Registrar, King's College (University of London), Strand, London, W.C.2 (November 17).

Senior Lecturer or **Lecturer in Physics**—The Registrar, The University, Manchester 13 (November 17).

Lecturer in the Department of Mathematical Physics—The Secretary, The University, Edinburgh (November 24).

Head (with a degree in applied mathematics) **of the Department of Mathematics and Physics**, Kumasi College of Technology—The Council for Overseas Colleges of Arts, Science and Technology, 12 Lincoln's Inn Fields, London, W.C.2 (November 25).

Chair of Mechanical Engineering—The Secretary, The Queen's University, Belfast (November 30).

Research Fellow in Heat Transfer, to pursue research into the mechanism of heat transfer from long pipes, carrying steam in the transition region from superheated to saturated—The Registrar, University College of Swansea, Singleton Park, Swansea (December 1).

Senior Lecturer in Mechanical Engineering—The Secretary, The Queen's University, Belfast (December 1).

Lecturer in Education at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 5)

Professor in Physiology at the University of Queensland, Australia.—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 15).

Lecturer and an **Assistant Lecturer in Genetics**—The Secretary of University Court, The University, Glasgow (December 31).

Director of the Commonwealth Bureau of Horticulture and Plantation Crops, East Malling Research Station, near Maidstone, Kent—The Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks (January 31).

Assistant Lecturer, Grade B (with a degree or equivalent and preferably industrial and/or teaching experience), **in Telecommunications**, to teach up to the Final Certificate of the City and Guilds of London Institute and the R.T.E.B. Radio and Television Servicing Certificates—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

Assistant (preferably with experience of biochemical or other techniques in microbiology), for research on the mode of action of antituberculous drugs—The Secretary, Guy's Hospital Medical School, London, S.E.1.

Fellow in the Department of Chemistry, for fundamental research on electron resonance spectroscopy—The Registrar, The University, Birmingham 15.

Junior Bacteriologist, to assist in the investigation of intestinal disorders of newborn animals—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1.

Laboratory Assistant (age about 30–35, experience of anatomical and biological laboratory techniques, and preferably an elementary knowledge of photographic processes and/or histological procedures)—The Establishments Officer, Zoological Society of London, Regent's Park, London, N.W.1.

Lecturers (2) (graduates of a British university and preferably specialists in experimental microwave physics or theoretical metal physics) **in Physics**—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

Professor (British subject with British university qualifications) **of Biochemistry** in the University of Teheran, Iran—The Director, Personnel Department, British Council, 65 Davies Street, London, W.1, quoting N.3(58).

Research Fellow (with a good research background and suitably qualified academically) **in Metallurgy or Solid State Physics** in the Department of Aircraft Materials—The Recorder, College of Aeronautics, Bletchley, Bucks.

Research Physicists (with a first- or good second-class honours degree) for (*a*) to exploit techniques for measuring flux and spectral distribution of neutrons from reactors and accelerators; and (*b*) to study and measure high energy (greater than 10 MeV.) radiations—The Group Recruitment Officer (1233/34), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Berks.

Technical Assistant in Electronics in the Isotopes Laboratory, for work which will involve the maintenance of routine counting equipment, as well as the designing and building of apparatus to research requirements—Joint Clerk to the University Court, Queen's College, Dundee.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Edinburgh School of Agriculture and Edinburgh and East of Scotland College of Agriculture. Calendar for 1958–1959. Pp. 100. (Edinburgh: Edinburgh School of Agriculture and Edinburgh and East of Scotland College of Agriculture, 1958.) 1*s*. [129

Planning, Vol. 24, No. 425 (25 August, 1958): Modern Cosmetics and Perfumery. Pp. 173–197. (London: Political and Economic Planning, 1958.) 2*s*. 6*d*. [129

Annual Report on the Meteorological Office for the year April 1, 1957, to March 31, 1958. Pp. 52+4 plates. (M.O. 650.) (London: H.M. Stationery Office, 1958.) 3*s*. 6*d*. net. [129

British Rubber Producers' Research Association. Twentieth Annual Report, May 1958. Pp. 57. (London: British Rubber Producers' Research Association, 1958.) [129

B.D.H. Biological Stains and Staining Methods: a Guide to the Use of B.D.H. Stains and Microscopical Materials. Pp. iv+34. (Poole, Dorset: British Drug Houses, Ltd., 1958.) [129

Third International Seaweed Symposium, Galway, August 13–19, 1958—Abstracts. Pp. xxx+82. (Galway: University College, 1958.) [129

Department of Scientific and Industrial Research. Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the year 1957, with Report of the Geological Survey Board. Pp. iii+75. (London: H.M. Stationery Office, 1958.) 5*s*. net. [129

Other Countries

Comptes Rendus des Travaux du Laboratoire Carlsberg. Série Chimique. Vol. 30, Nos. 21–27: The Optical Rotatory Properties of Proteins and Polypeptides. By John A. Schellman and Charlotte Schellman. Pp. 363–500. 11 kr. Vol. 31, No. 1: Some Observations on Sporulation in *Saccharomyces*. By A. T. Ganesan, H. Holter and C. Roberts. Pp. 1–6. 50 øre. Vol. 31, No. 2: Changes in Submerged (Reduced) Weight Associated with Cell Division in Echinoderm Eggs: a Study with the Cartesian Diver Balance. By W. L. M. Geilenkirchen and E. Zeuthen. Pp. 7–28. 1 kr. 80 øre. Vol. 31, No. 3: The Equilibria of an Enzyme, Hydrogen Ion and a Virtual Substrate. By Fred Vaslow. Pp. 29–40. 1 kr. Vol. 31, No. 4: Iron Absorption in Different Species as a Function of the *p*H Value of the Solution. By Garsten Olsen. Pp. 41–60 (1 plate). 1 kr. 60 øre. Vol. 31, No. 5: The Influence of CO_2 Tension on Cellular Respiration Studies by the Cartesian Diver Technique. By B. Shannon Danes and Jørgen Kieler. Pp. 61–76. 1 kr. 20 øre. (Copenhague: Danish Science Press, Ltd., 1958.) [119

Institut pour L'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. Rapport Annuel Exercice 1957. Pp. 231. (Bruxelles: Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1957.) [119

Informator Nauki Polskiej. Pp. 556. (Warszawa: Panstwowe Wydawnictwo Naukowe, 1958.) [119

Indonesian Chemical Nomenclature. Pp. 35. (Djakarta: Madjelis Ilmu Pengetahuan Indonesia, 1958.) [119

Indian Journal of Applied Chemistry, Vol. 21, No. 1 (1958). Pp. 60. Published bi-monthly. Annual subscription Rs. 12. Single issues Rs. 3. (Calcutta: Indian Chemical Society, 1958.) [119

Aligarh Muslim University Publications: (Zoological Series). On Indian Insect Types. Edited by Prof. M. B. Mirza. 5: The Morphology and Life-History of *Leptocorisa varicornis* Fabr. (Coreidae, Hemiptera)—a Pest of Paddy Crop in India. By Dr. S. Shujaatul Akbar. Part 2: Abdomen—Internal Anatomy and Life-History. Pp. i+50+7 plates. (Aligarh: Muslim University, 1958.) Rs. 5. [119

Indian Central Jute Committee. Annual Report for the year 1956–57. Pp. xxvii+278. Annual Report of the Jute Agricultural Research Institute (1956–57). Pp. 121. (Calcutta: Indian Central Jute Committee, 1958.) [119

Commonwealth of Australia. Annual Report 1956–57 of the Aeronautical Research Laboratories. Pp. 26. (Melbourne: Aeronautical Research Laboratories, Department of Supply, 1958.) [119

International Atomic Energy Agency. Programme and Budget for 1959. Pp. vii+94. First Annual Report of the Board of Governors to the General Conference covering the period from 23 October 1957 to 30 June 1958. Pp. ii+53. (Vienna: International Atomic Energy Agency, 1958.) [119

Deutsches Hydrographisches Institut, Hamburg. Jahresbericht Nr. 12 für das Jahr 1957. Pp. 76. (Hamburg: Deutsches Hydrographisches Institut, 1958.) [119

United States Department of Agriculture. Agriculture Information Bulletin No. 182: The Oriental Fruit Moth. By H. W. Allen. Pp. 28. (Washington, D.C.: Government Printing Office, 1958.) 15 cents. [119

Occasional Papers of the Natural History Museum of Stanford University. No. 6 (July 25, 1958): A New Genus and Species of Arboreal Scincid Lizards from the Palau Islands. By Walter C. Brown and Adair Fehlmann. Pp. 7. (Stanford, Calif.: Natural History Museum, Stanford University, 1958.) [119

United States Department of Commerce: Weather Bureau. Technical Paper No. 15: Maximum Station Precipitation for 1, 2, 3, 6, 12, and 24 hours. Part 22: Ohio. Pp. ii+137. (Washington, D.C.: Government Printing Office, 1958.) 65 cents. [119

Ghana Department of Agriculture: Division of Soil and Land Use Survey. Occasional Paper No. 1: Report on the Environmental Conditions Prevailing in Block 'A', Southern Province, Tanganyika Territory. By C. F. Charter. Pp. iii+37. (Accra: Government Printing Department (Publications Branch); London: Crown Agents for Oversea Governments and Administrations, 1958.) 5*s*. [119

Connecticut Agricultural Experiment Station. Bulletin 615 (June, 1958): Periodic Regression in Biology and Climatology. By C. I. Bliss. Pp. 55. (New Haven, Conn.: Connecticut Agricultural Experiment Station, 1958.) [119

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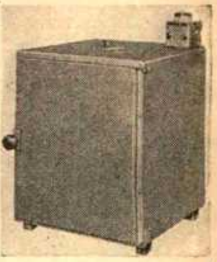

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THE AGRICULTURAL RESEARCH COUNCIL

THE report of the Agricultural Research Council for 1956–57* covers the first year of operations under the Agricultural Research Act, 1956, which made the Council directly responsible to Parliament and not to the Treasury for its expenditure on agricultural research. Under these new arrangements the Council has taken over responsibilities that the Ministry of Agriculture had in financing State-aided agricultural research centres in England and Wales. The total vote by Parliament to the Agricultural Research Fund for 1956–57 was £3,626,000, and this was allocated to a very wide range of research, much of it of a fundamental nature.

One very pleasing feature of the work is the substantial number of 'research units' which are set up in close association with universities and usually with the head of the university department as its honorary director. Men like Prof. F. G. Gregory, with his Research Institute of Plant Physiology at the Imperial College of Science and Technology, London, and Prof. K. Mather, with his Unit of Biometrical Genetics at Birmingham, are assisted by the provision of staff and facilities to develop research programmes which could not otherwise be undertaken. In addition, direct grants are given to universities to enable research on specific projects of shorter duration. Nearly every university in Great Britain is represented in this list, and virtually every science basic to agriculture is included. Then there are the research studentships and fellowships, numbering 75 in all, to promote the training of research workers, mainly in universities. By following such a policy not only is the Council safeguarding the supply of trained staff for the large State-aided or financed research institutes which are its main concern, but also it is helping in providing the stimulus of lively research at teaching centres.

The list of research institutes is a long and impressive one. At the head of the list is Rothamsted, which was once financed by a private endowment from its founder, Sir John Lawes. Now 90 per cent of its funds are provided by the Agricultural Research Fund. Plant breeding is very well catered for, and there are three major institutes concerned with this work, while there are other centres with plant breeding departments. Here, one detects a certain lack of balance, for considerably less emphasis is placed on animal breeding for, apart from poultry (which is well served), there is only one major organization concerned with this very important field. It is not suggested that plant breeding should receive less attention so that animals should receive more, but that animal-breeding studies should, in their own right, receive more help, for animal production constitutes the major part of total agricultural production in Great Britain. Though the beef industry is one of the most important branches of farming, apart from some reference to the genetics of beef and milk production in dual-purpose cattle at the University of Edinburgh and carcass-quality studies at Cambridge, there appears to be little concern for the future of the roast beef of England.

On the other hand, the dairy industry is well catered for with two large institutes at Reading and Ayr, and here again this emphasizes the need for the projected Meat Research Institute to co-ordinate and assist the limited amount of research which is being undertaken with meat animals.

Another major deficiency of immediate concern is the poverty of research into farm buildings. The Agricultural Research Council has a special committee on this, headed by the Council's chairman, but so far matters do not appear to have progressed much beyond the committee stage. The State, however, has committed itself to a very expensive farm improvement scheme ; but there is not the basic information on building design to ensure the thrift of housed stock or to secure a fuller economy of labour.

But one must not judge the work of the Council by such deficiencies, for there is so much that is good that has been achieved. There is the better understanding of husbandry control of internal parasites that has come out of the work of the Grassland Research Station at Hurley ; there is the Wye College contribution on MCPB to give a herbicide which does not injure clovers ; the new winter oat Powys that Aberystwyth has bred, and a dozen more instances of really valuable advances. Especially is this true on the veterinary side, where Britain preserves its long-established leadership. The value of this work in one field may be instanced by a quotation from the report on the Moredun Institute : "Not more than thirty years ago there were in Britain nineteen major diseases of the sheep, of which the causes were unknown. To-day, in eighteen of these diseases the cause has been demonstrated and in fourteen of them specific means for cure or prevention have been evolved". This is a fine record, and one would imagine that these advances in controlling sheep diseases alone have effected an annual saving more than sufficient to fund the whole cost of the Agricultural Research Council's work.

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* Committee of the Privy Council for Agricultural Research. Report of the Agricultural Research Council for the year 1956–57. Pp. iv + 152. (Cmnd. 432.) (London : H.M. Stationery Office, 1958.) 7s. net.

SCIENTIFIC DEVELOPMENT AND THE UNIVERSITIES

Technology and the Academics

An Essay on Universities and the Scientific Revolution. By Sir Eric Ashby. Pp. vii+118. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 15*s*. net.

THE substance of this book is the series of Ballard-Matthews Lectures which Sir Eric Ashby gave in the University College of North Wales at the beginning of this year. It is a fascinating book and a timely one. It is also a courageous book. The problems raised are set in a wide background and put forward in a way which must appeal to a far wider public than those who are more immediately concerned with their solution.

The writer's thesis is the split personality which exists in British universities to-day. He outlines the four functions which the universities are attempting to fulfil: their functions to train people for the professions, to act as a nursery for gentlemen, statesmen and administrators, to provide a centre for scholarship and research, and to serve as a staff college for technological experts and specialists. It is startling and, at the same time, refreshing to find an analysis of the functions of a university in such simple and down-to-earth terms. The problem is to reconcile these four different functions in one and the same institution. As one would expect, the writer draws frequently on biological analogy. "In social institutions as in living organisms form and function are inextricably bound together. If function changes then form must adapt itself or the organism—and the institution—will perish." Adaptation in the universities is, it is maintained, by no means complete, and form is not everywhere fitted to function.

The first three chapters of the book are devoted mainly to a description of the reasons why, and the manner in which, technology became a university function in Great Britain. There is an absorbing first chapter on the development of science in the continent of Europe, the reasons for lack of enthusiasm at that time in British universities (that is, Oxford, Cambridge and the Scottish universities) for scientific thought, though British scientists individually played a notable part in the development of science in the eighteenth and early nineteenth centuries. He traces the early developments in France, "the mother of organized research", the export of science across the Rhine but not across the Channel and then the development of the German universities and Technische Hochschulen. The second chapter is devoted to the much later development in Great Britain, the influences which brought about the changes in Oxford and Cambridge and the growth of university colleges. There are some stimulating, and perhaps controversial, thoughts on the results of the impact of science on the universities, their impetus to the growth of intellectual freedom, the democratization of the academic world, and the growth of a cosmopolitan and even international spirit in the universities. Ashby then comes to their adoption of technology and shows how the differences in our environment led not to a facsimile of the continental institutions but to something very different and probably more fundamentally sound. The reasons for the development of technology within university precincts, rather than in separate institutions, are of particular interest to-day when efforts are being made on the Continent and in the United States to broaden and strengthen technology by bringing it into closer contact, both for staff and students, with the pure science and the humanities, to the mutual benefit of all three.

The symptoms of schizophrenia are the basis of the concluding chapters and the diagnosis is an able one. Finally, one cannot but refer to the delight of reading a book of such fundamental importance which is written in so engaging a way; its literary style, as one expects from Sir Eric Ashby, is impeccable. While there is an exceptional awareness of what has gone on and is going on both in Great Britain and overseas, there is a complete absence of that ostentation which too often accompanies so great a wealth of knowledge.

TECHNIQUES IN SOCIOLOGY

Survey Methods in Social Investigation

By C. A. Moser. (Heinemann Books on Sociology.) Pp. xiii+352. (London: William Heinemann, Ltd., 1958.) 35*s*. net.

IT is made plain in the introductory chapter of this book that the techniques with which it deals are more relevant to 'extensive' rather than 'intensive' inquiries; that is to say, it is primarily concerned with official surveys of the kind conducted by the Central Office of Information, market and opinion research, and the large-scale operations of social scientists. This is also evident from the fact that approximately a third of the book is devoted to the application of sampling methods, and a discussion of the problems that arise in the use of samples.

Although the book must, therefore, be regarded as restricted in its scope, despite its title, the introductory section also contains a discussion of the general nature of social surveys; it also ends with a broader treatment of methods of collecting information, including the use of documents, questionnaires, and interviewing, and a discussion of the methods of processing the data so obtained.

So far as the nature of social surveys is concerned, Mr. Moser points out very wisely that fact-collecting is no substitute for serious thought, remarking that "it is the ill-considered launching of surveys, leading to the waste of much time and money and the accumulation (often) of unwanted data, that has given rise to the scepticism with which some sociologists regard 'door-knocking' research." "It is no good," he adds, "blindly to apply the formal standardized methods generally used in official or market research enquiries, to many of the more complex problems in which sociologists are interested." This is all too true, but the comment would have been all the more valuable if it had been based on actual examples, of which there are many. Sociologists must be helped to learn from their mistakes, painful as the experience may be.

The main section of the book on sampling methods provides a useful text on which those actively engaged on large-scale inquiries can rely. So far as the collection of the raw data is concerned, on the accuracy of which the value of every survey is ultimately dependent, Mr. Moser is entirely correct in saying that problems arise which are different in kind, rather than in degree, from those arising out of sampling. This is an obvious point. Much more attention should be directed to it rather than, for example, to the more elementary processes of sampling which are apt to be explained and discussed *ad nauseam*.

As Mr. Moser puts it, "our knowledge of data collection is, by comparison, primitive . . . One part of the survey process is tackled by a tool of high precision that makes accurate estimates of errors possible, while in the other parts errors of generally unknown proportions subsist". The impression is thus given that the high degree of accuracy with which the results of large-scale surveys are frequently stated may be misleading, perhaps very misleading indeed. This is probably true. Much more research into this difficult problem is required.

T. S. Simey

PLANTS OF THE FARM

Agricultural Botany

By Dr. N. T. Gill and K. C. Vear. Pp. viii+636. (London: Gerald Duckworth and Co., Ltd., 1958.) 63*s*. net.

Although botany began as the collection of information about economic and medicinal plants, the modern teaching subject of agricultural botany emerged as an eclectic version of 'pure' botany, based on economic examples. This was the plan of the late Prof. Percival's well-known textbook, even up to its last edition in 1936. Since the turn of the century, however, several fields of endeavour have developed a structure and outlook of their own. Thus, plant pathology and plant breeding are to-day largely independent disciplines, recognizably distinct in their methods of thought and action from mycology or genetics. Comparable trends are evident in crop physiology. The subject as a whole seems to be developing a coherent unity along lines indicated in part by Vavilov, and based upon the ecological connexions between its parts. This may well lead agricultural botany to a relationship to pure botany not unlike that of engineering to physics.

Against this background the present work is distinctly disappointing. It consists of a reasonably detailed and well-illustrated conspectus, on a taxonomic basis, of the agricultural and horticultural plants and weeds of temperate regions, with some tropical crop species added (400 pages), sandwiched between very much less satisfactory and far less well-illustrated accounts of plant breeding and plant diseases (about 100 pages each). Its stated aim is to meet the requirements of agricultural diploma and pass-degree students; but it would seem that many of them will find the systematic part more than adequate for their needs, while remaining unsatisfied by the remainder.

More serious than this lack of balance is the almost complete absence of any account of the extensive modern work on the physiology and ecology of crops and weeds. Yield is usually the most important characteristic of economic plants. The analysis of plant growth and yield is consequently an essential part of the contribution botany can make to farming; indeed, it can be thought of as the theoretical basis of agriculture. Yet the outstanding advances of the past thirty years in the study of the crop as an assemblage of growing and competing plants, continuously influenced by varying environmental factors, is not reflected in these pages.

The principal merit of the book, then, lies in the systematic description of agricultural plants, which fills a need by bringing together a useful body of fairly up-to-date information not elsewhere available in one volume. For this the work may be recommended, though the price may seem unduly high to some.

A. H. Bunting

". . . THE EAST WIND BROUGHT THE LOCUSTS"

Insect Migration

By Dr. C. B. Williams. (The New Naturalist: a Survey of British Natural History.) Pp. xiii+235+24 plates. (London: William Collins, Sons and Co., Ltd., 1958.) 30*s*. net.

Among British entomologists who have worked in the tropics within the past generation, there are probably not many for whom a visit to Rothamsted has not provided stimulation, together with an injunction from Dr. C. B. Williams to keep a look-out for butterfly migration. All who heeded his injunction, and all who know his comprehensive and critical book on this subject, published in 1930, will welcome this entertaining and copiously illustrated addition to the admirable "New Naturalist" series.

The present book, however, is perhaps one to arouse interest rather than to satisfy it. A serious reader, seeking to follow up some tantalizing allusion, and undaunted by an absence of references in the text, is still likely to be frustrated by the slim bibliography, with its sixteen titles since 1942, out of the several hundred of which Dr. Williams tells him—and makes use. Moreover, in the introduction the author makes a distinction between deliberate migration and drift on the wind, and he defines migration as "a continued movement in a more or less definite direction, in which both movement and direction are under the control of the animal concerned". But he does not say a great deal about the extent to which the material he presents satisfies his own definition: some species appear to be described as migrants mainly because they are often seen a long way outside their breeding areas—without much consideration of any contribution which may be made to these geographical displacements by the winds at the time.

Dr. Williams's editors suggest that his book may almost be regarded as a world detective story; and he tells how, for locusts, the original case for deliberate long-range migration appears to have collapsed under the evidence of synoptic meteorology. But in this book his own approach sometimes suggests the compiler of criminological statistics rather than the detective. Thus, eleven pages of tables, and four figures, demonstrate that a number of species of butterflies and moths have been recorded in Britain more frequently in some years than in others; but there is little examination of any possibility of an association of environmental conditions with such occurrences and their fluctuations—which is the more disappointing in view of Dr. Williams's own pioneer work on the effects of weather on insect populations.

But his readers, like the followers of the best detectives, will look forward to meeting him again as he deals with new evidence. Urquhart has reported flights of up to 2,000 miles by individual marked Monarch butterflies in North America: details of such flights, which are still awaited, and of the wind-systems encountered during them, may perhaps provide the first rigorous demonstration of long-range insect migration in the strict sense of Dr. Williams's definition. R. C. Rainey

HYDROGEN ION CONCENTRATION AND ACTIVITY

A Dictionary of pH Applications

By R. S. Evans. Pp. viii+78+xviii. (London: The Herbert Publishing Company, Ltd., 1957.) 10*s.* 6*d.* net.

The Book of pH

A simple and complete Description of the Theory and the Practice of the Measurement of *p*H as applied to Science and Industry. By R. B. Webber. Pp. 111. (London: George Newnes, Ltd., 1957.) 30*s.* net.

That two books on the applications of *p*H to industrial processes should appear together is a remarkable coincidence. Mr. R. S. Evans's book is sponsored by W. G. Pye and Co., Ltd., of Cambridge, and Mr. R. B. Webber's by Tintometer, Ltd., of Salisbury. Both books are designed to impress the industrialist, who, incidentally, is assumed to have no chemical knowledge, of the great importance that *p*H data may be to him and yet how very simple it is to make *p*H measurements. In the first, it is stated that glass-electrode *p*H meters are rapidly replacing colorimetric methods, which are not even described, while in the second, colorimetric and electrometric methods are very simply discussed, but it is emphasized that colorimetric methods are very much easier to operate, especially if use is made of the Lovibond comparator and Nessleriser in conjunction with permanent colour standards (of glass) which correspond with the colours of indicators at specified *p*H values, and which are mounted in a rotating disk to facilitate comparison. To estimate the *p*H of unbuffered, or poorly buffered, solutions, when it is essential to use as low a concentration of indicator as possible, the Nessleriser is used. In this method it is assumed that the effect of the *p*H of the indicator itself is rendered negligible. It would have been better if the isohydric indicator method had been given, but perhaps the reason for its omission is to be found in the assertion made on p. 81 that "the operators need not be particularly intelligent or skilful" to carry out colorimetric determinations.

Explaining the meaning of *p*H to the uninitiated is obviously something of a problem. Evans is content to leave the problem by saying that the *p*H value "may loosely be defined as a measure of acidity or alkalinity", whereas Webber starts off by stating that "the concept of *p*H is fundamentally very simple" and likens the *p*H scale to the centigrade scale of temperature, each number of the *p*H scale having "an exact meaning". Later, he declares that "the *p*H story is not an over-simple one". In the middle of the book he gives the mathematical expression which relates *p*H with hydrogen ion concentration, but towards the end he attempts to explain that it would be better to substitute activity for concentration. It must be comforting to the reader to be told that whichever view is accepted it will only make a difference in the observed *p*H value, within the *p*H range 2–12, of ± 0·02 *p*H unit.

Webber includes a couple of pages on measuring the hydrogen ion activity of non-aqueous solutions and refers to the *c*G scale which J. B. Conant introduced many years ago but which has not been seriously regarded. Such a discussion might be considered to be out of place in a book of this type.

Both volumes might be considered to have fulfilled a need, but that of Webber has done so more effectively. H. T. S. Britton

APPLIED ACOUSTICS

Acoustics, Noise, and Buildings

By P. H. Parkin and H. R. Humphreys. Pp. 331. (London: Faber and Faber, Ltd., 1958.) 70*s.* net.

In post-war Britain classical physics has been much neglected because of the great attractions of nuclear physics. Consequently, activity in Great Britain on the subject of acoustics is on a very small scale, although slightly more is now done than before the War, when the subject was practically ignored. In the United States and on the continent of Europe, on the other hand, much more work is done, and considerable effort goes into research and investigation. It is therefore not surprising that, although several text-books have been published in Europe or in America and some of the European books have been translated into English, the last important book was "Acoustics" by the late Alexander Wood, published in 1940. Messrs. Parkin and Humphreys are therefore to be congratulated on writing the present volume, which fills a long-felt want.

This book is not intended to be a text-book but a survey of the subject for those not qualified in physics, such as architects, engineers and others who may be interested in acquiring a reasonable knowledge. The first two chapters on the "Nature of Sound" and "The Behaviour of Sound in Rooms" are in elementary terms to act as an introduction to the subject. Chapter 3 describes "The Design of Rooms for Speech" and should be of great value to individuals interested in the improvement of the acoustics of theatres, lecture rooms, classrooms and similar buildings. Chapter 4 describes a much more specialized field, "The Design of Rooms for Music". The description of the various factors affecting design is very lucid, and most of the difficulties are described in considerable detail. Greater emphasis might, however, with advantage have been placed on the fact that the final criterion for such rooms is æsthetic and that personal opinion plays a large part in the final judgment. Chapter 5, "The Design of Studios", describes the design of studios for broadcasting, which is a very specialized field indeed.

Another feature of post-war civilization seems to be the absence of the orator capable of addressing a large audience without assistance from electroacoustic devices. 'Public address' has consequently become firmly established even in quite small auditoria. Chapter 6, "The Design of High Quality Speech-Reinforcement Systems", is therefore a very valuable contribution and is particularly interesting for its description of the methods used for speech-reinforcement in very large cathedrals such as St. Paul's and Salisbury. In such enormous buildings with very long reverberation times it has never been possible for the congregation to hear the service properly. In these circumstances, speech-reinforcement systems are the only solution. In the case of very large arenas, speech-reinforcement is also essential. It is to be hoped that the designers of speech-reinforcement installations, which up to the present have been extremely unsatisfactory except as an emulation of Donald Duck, may profit by the details given in this book.

Almost half the book, commencing at Chapter 7, is given up to the problems of noise, which is one of the most pressing problems in modern times. Chapter 7 describes various types of noise and their effects, while Chapter 8 gives a detailed description, in simple terms, of "Sound Insulation and Noise Control Practice" in all types of building. The details of "Sound Measurement and Calculation" are given in Chapter 9. Chapter 10 provides details of "Criteria for Sound Insulation and Noise Control", which is a very useful summary of the present position.

This book is well written and should prove of great value as a general survey of the subject. In several places where differences of opinion are known to exist, the authors might with advantage have indicated the regions of controversy. This is particularly noticeable in the chapter on "Sound Measurement and Calculation", some parts of which are the subject of argument at international conferences. The value of the book might perhaps have been increased, without appreciable increase of effort on the part of the authors, by providing references to the considerable literature in this field, since this would make it easy for an interested reader to follow up any particular problem on which he requires more information.

T. SOMERVILLE

THEORY AND APPLICATION OF INTEGRAL EQUATIONS

Integral Equations

By Prof. F. G. Tricomi. (Pure and Applied Mathematics: a Series of Texts and Monographs, Vol. 5.) Pp. viii+238. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 7 dollars.

Integral Equations and their Applications to Certain Problems in Mechanics, Mathematical Physics and Technology

By S. G. Mikhlin. Translated from the Russian by A. H. Armstrong. (International Series of Monographs on Pure and Applied Mathematics, Vol. 4.) Pp. xii+338. (London and New York: Pergamon Press, 1957.) 80*s.* net.

THE systematic study of integral equations was stimulated about 1900 by the somewhat sensational work of Fredholm in providing a proof of Dirichlet's principle asserting the existence of a solution of Laplace's equation under given boundary conditions. The wealth of ideas in Volterra's pioneer work began to be appreciated; and by 1908 or so the main lines of the classical theory had been laid down, with major contributions from Hilbert and Schmidt. The linear Fredholm and Volterra equation involves a term of the type:

$$\int K(x,y)\,\varphi\,(y)\,\mathrm{d}y$$

where integration is over a constant range in the Fredholm equation, and from 0 to x in the Volterra equation, φ is the unknown, and K is a given function, the kernel. The method of successive approximation can be used to obtain formal solutions, as infinite power series in a parameter λ; but in the Fredholm case, the series does not necessarily converge for all λ, and Fredholm's great contribution was to replace the series by the quotient of two integral functions of λ. When the kernel is symmetric, $K(x,y) = K(y,x)$, connexion with orthogonal systems of functions is almost immediate, and leads to the Hilbert–Schmidt theory. If the kernel is of the form $H(x,y)/(x-y)^a$, so that the integral must be defined as a 'principal value', the equation is said to be singular, as are many of the equations which turn up naturally in applications, and we owe to Carleman the origins of two methods of coping with such equations. Nonlinear equations have also come recently into prominence again, though Schmidt began their investigation some fifty years ago.

All this theory is set out beautifully by Tricomi, in a most readable book. The material is deliberately restricted to the classical theory, but there are numerous references to guide the reader to further work on the theory and to the wide field of recent applications. Great care has been taken with the presentation; the reader will require only a sound knowledge of elementary analysis. An acquaintance with the Lebesgue integral is desirable, since the main conditions on the kernel is simply that the two-variable integral of $|K|^2$ shall be bounded, but even this knowledge is not absolutely essential. Of introductions in English, French or German, this seems to me the most attractive.

Linguistic difficulties have not entirely concealed the fact that in recent years great progress in the application of integral equations to physical problems has been made by Russian mathematicians, particularly by those centred at Tiflis. Two recent translations of books by Muskhelishvili, on elasticity and on singular integral equations, have helped to make this work accessible, and now this translation of the second edition of Mikhlin's book has added to our knowledge. It is in two parts: the first 130 pages cover much the same ground as does Tricomi's book, more concisely and with slightly more demands on the reader. The remaining 200 pages are devoted to applications, starting from the basic Dirichlet principle, and concerned chiefly with elasticity, hydrodynamics and aerodynamics. Here, of course, it is necessary that the reader should have a sound knowledge of the fundamental principles of these topics, such as a good honours degree student should possess. The problems are culled from a wide field, but are mainly one-dimensional or two-dimensional; the author remarks that the accusation of ineffectiveness sometimes levelled at integral equations is not without justification when problems in three dimensions are involved; here, no doubt, is a field for further research.

This systematic exploitation of a powerful method is most welcome. The translation reads smoothly almost everywhere; but there are some references in the text (for example, pp. 234 and 264) to items which do not appear in the bibliography.

T. A. A. BROADBENT

UNESCO HOUSE, PARIS

ON the architects of to-day rests the responsibility of designing the heritage of to-morrow. But few architects in any era can have faced a task so onerous as the planning of the Unesco headquarters in Paris—an edifice that at one and the same time had to embody the spirit of modernism inherent in the United Nations Educational, Scientific and Cultural Organization, provide a functional base for its activities and blend with neighbouring buildings that had already spanned the centuries. That this has been accomplished is due to three internationally eminent architects, Marcel Breuer (United States), Pier Nervi (Italy), and Bernard Zehrfuss (France), who prepared the original plans, and a consultative panel consisting of Lucio Costa (Brazil), Walter Gropius (United States), Charles Le Corbusier (France), Sven Markelius (Sweden), and Ernesto Rogers (Italy), who approved them. Eero Saarinen (United States) also acted in an advisory capacity, and Eugene Callison (United States) supervised the building operations.

The Unesco headquarters, which was formally opened on November 3, is made up of three buildings. The most dominating of these is the Y-shaped seven-storied secretariat on the Place de Fontenoy. Viewed from the Eiffel Tower—which in its time had to pass through periods of acute criticism, ardent admiration and strong dislike before being accepted as a landmark of the great city—the frontage of the secretariat completes a semi-circle with a French ministerial building and combines to provide an effective background for the eighteenth-century Ecole Militaire.

Though it complements the surroundings so beautifully, the new building is still strikingly modern. Mounted on up-thrusting *pilotis* which give an even greater impression of height than its actual 94 ft., it bears the same relationship to its brick and stone companions as a jet airliner has to its bi-plane predecessors.

Six hundred offices are accommodated in the building, spreading out from the central point of the Y. While, on the exterior, the windows, numbering more than a thousand with a glass area of some 72,981 sq. ft., give the building a shimmering appearance, in the rooms the light is equally distributed with a clarity that reduces the need for artificial lighting to a minimum even on the dullest days.

The conference building, which is connected with the secretariat by an impressive hallway, owes its main impact to its fluted concrete walls and 'butterfly' roof covered in copper. Here in a deceptively small area (35,327 sq. ft.) are housed the main conference halls and committee rooms, including the Plenary Hall with accommodation for almost a thousand people, a Main Commission Room with 270 seats at tables for delegates and observers and 77 seats for the public, an Executive Board Room which can also be used by one of the large commissions and five smaller committee rooms with seating accommodation

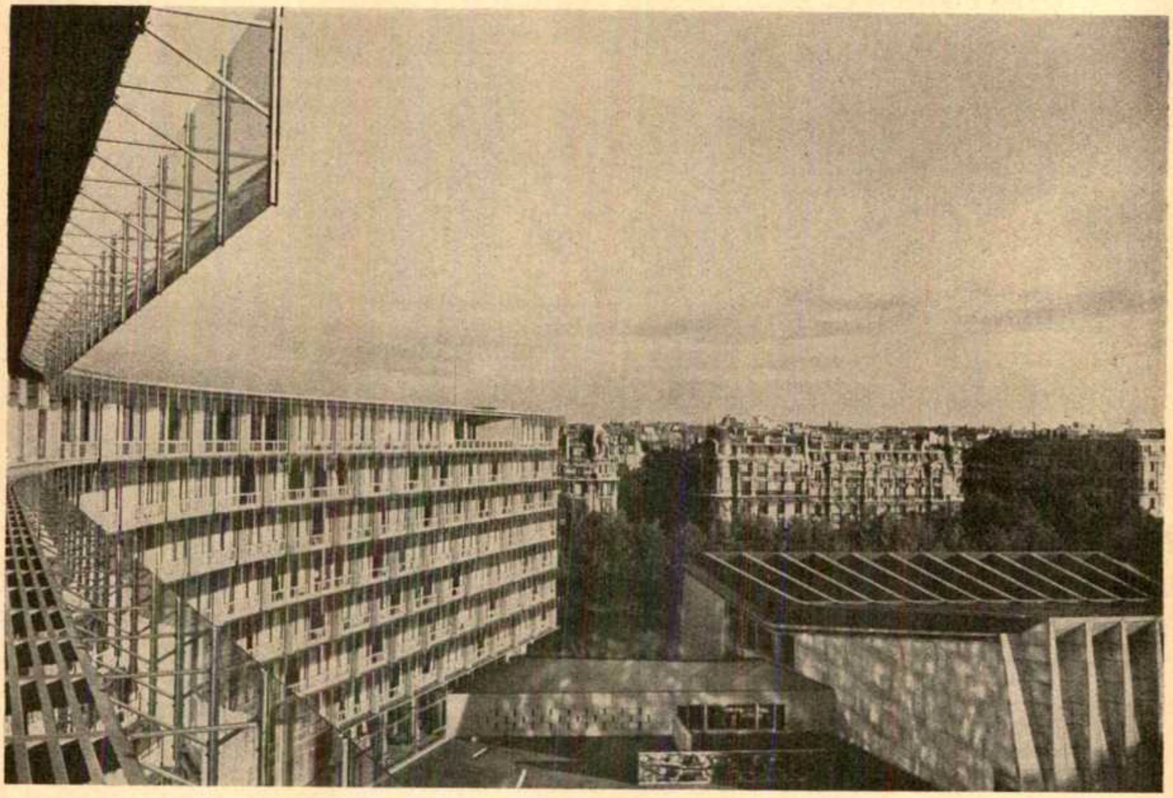


Fig. 1. Unesco House, Paris. Façade in Avenue Suffren

Photo: Unesco–Berretty

fees, materials, the installation of contributions from Member States, etc., they commissioned the following works of art: Paintings by Afro (Italy), Appel (Netherlands; Fig. 3), Matta (Chile), and a photographic panel by Brassai (France) for the lounge, restaurant and cafeteria of the seventh floor; a mural by Picasso (Spain) for the wall in the delegates' hall and a fresco by Tamayo (Mexico) for the commission room; a bronze haut relief by Arp (France) for the outside Library wall and for the grounds an eye-catching mobile by Calder (United States), a massive travertine figure by Moore (United Kingdom) and two ceramics designed by Miro and executed in co-operation with Artigas (Spain). Noguchi was entrusted with the task of designing a garden in the Japanese style, for which the Japanese Government sent stones and plants.

No attempt has been made to build a monumental pile dedicated to posterity. This is a strictly utilitarian setting for a working organization, and Unesco, while appreciating to the full the practical facilities it offers, still takes greater pride in being party to the establishment of a school, no matter how small, the opening of a library or the equipping of a laboratory in pursuance of its main aim of peace through universal understanding.

HEALTH AND SAFETY IN THE FIELD OF NUCLEAR ENERGY

THAT the development of atomic energy involves important contributions from a wide range of disciplines is generally accepted. This is true also in respect of the more limited field of the health and safety aspects and was well illustrated in the second United Nations International Conference on the Peaceful Uses of Atomic Energy held in Geneva in September, where some 170 papers were contributed on subjects either directly concerned with, or closely relevant to, the problems of radiation safety. The time available, however, allowed only a small number of these papers to be read and discussed. The progress in biology has been reported in a previous article (see *Nature*, October 25, p. 1118), and, although reports continue to be received of reversible biological response for exceedingly small doses of ionizing radiation, the evidence at Geneva tended to support the basic levels currently adopted for permissible occupational exposure.

Control of Occupational Exposure

Several important papers gave factual information concerning the doses experienced in the atomic energy work in a number of countries having large or small atomic energy projects. One paper, from Canada, showed that the recent reduction in the permissible mean annual dose from 15 r. per annum to 5 r. per annum had been fairly successfully followed in the occupational exposures incurred. Some of the papers, such as one from Great Britain, reported not only external radiation doses but also the control of internally assimilated isotopes, air and surface contamination, urine data, and the instances where contaminated wounds had been dealt with. Another paper of considerable interest summarized experience of radiation exposure in a number of industrial factories, the work of which involved exposure to ionizing radiation; it was emphasized that in most instances radiation protection in such factories has to be achieved with far fewer protection personnel than is considered necessary in atomic energy plants. A further important paper from Canada described recent experiences in the protection of health in uranium mining. Ever since pre-war days, when a high incidence of occupational bronchial carcinoma was observed as a result of long periods of work in certain uranium mines, the subject of the protection of uranium miners has been of considerable concern. The Canadian paper indicated how the very real difficulties of good radiological control have been met in Canadian mines.

A further aspect of operational experience was shown by many papers dealing with the design of plant and equipment for safety, and an excellent example was a description in an American paper of the extraordinarily complex installation utilized for the processing of high-activity alpha-active materials in chemical and metallurgical procedures. Such installations represent heavy capital investment devoted essentially to providing virtually a guarantee of radiation safety in handling these highly toxic materials.

Control of Environmental Hazards

One technical session was devoted to this subject, on which fifty-seven papers had been contributed. The papers included a comprehensive review of the control of environmental hazard around the Hanford Plant in the United States, and also a paper from Great Britain giving the detailed radioactivity measurements on biological materials in the environment, such as milk, herbage and crops, following the nuclear reactor accident at Windscale in October 1957. (A brief synopsis of the Windscale data was presented in articles in *Nature* of September 6, p. 627.) In this session also a few papers dealt with the important subject of the fate of radioactive materials in soils and the transport through the soil – plant – animal food-chain. Other papers on this subject appeared in a further session on the uses of radioisotopes in agriculture. Problems of the discharge of liquid wastes were also covered, and included a report from Great Britain on experience in discharging large-volume dilute wastes to coastal waters. A study by the U.S.S.R. of the rate of turn-over of water in deep-water ocean depressions showed that the previous estimates of the time taken for water in these depressions to exchange with surface waters had perhaps been over-estimated, and the Russian report, which covered many of the known ocean-deeps, concluded that the disposal of very large amounts of activity in such depressions would be likely to lead to hazard.

The World Meteorological Organization presented a survey showing the importance of meteorology to safety problems in atomic energy, not only in the obvious instances of a reactor accident involving airborne release but also under normal operating conditions. In various sessions of the Conference

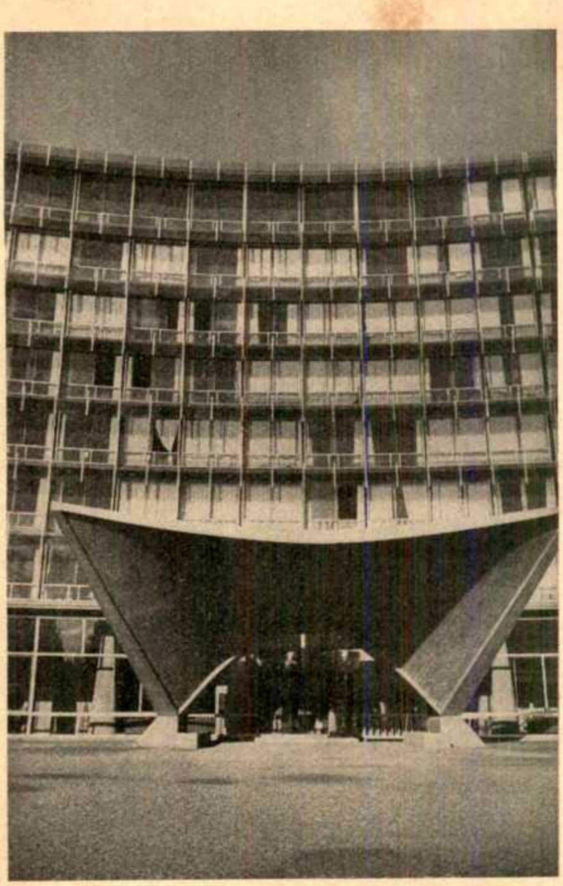


Photo: Unesco–Berretty

Fig. 2. Unesco House. Entrance from Avenue Suffren

ranging from 25 to 45. A special hall for international non-governmental organizations has also been provided along with ten offices and a Press room.

The permanent delegations to Unesco have been given offices in the third building, which follows the same exterior design as the secretariat building.

That these buildings should be constructed of the most modern—and cheapest—building material, namely, reinforced concrete, was not purely a budgetary decision. The limitation of funds (the ceiling was 9,010,000 dollars financed by interest-free loans from the French Government) imposed a certain degree of economy, but at the same time it was felt that the plasticity of concrete would give the desired freedom of architectural form and also be in keeping with the Organization's desire for functional simplicity.

The result is a pleasant contrast achieved by the juxtaposition of rough-surfaced concrete with Roman travertine and Brittany granite, the tone values being heightened by judicious use of wood for the window casings and other strappings. Great imagination has been used in the exploitation of the decorative worth of these construction materials, and even the concrete *pilotis* completely unadorned in themselves have a grace and force reminiscent of the pillars of ancient Greek temples.

But it is in the conference building that the extreme versatility of concrete is seen to best advantage. Here the fluting of the walls—fold after fold in wide corrugations—which adds so greatly to the æsthetic appearance, also has the practical result of ensuring perfect acoustics for the conference chambers. Similar unusual effects have been obtained by a fire staircase of pre-fabricated concrete blocks that winds its way in a spiral up one of the wings and by the canopy composed of two curved concrete surfaces that gives a dramatic quality to the doorway facing Avenue Suffren (Fig. 2).

An important part in making the headquarters what they are to-day is due to the Member States of Unesco. Engineers, furniture designers, electricians, office specialists, sound technicians, and industrial experts from ten countries have given an aura of internationalism to the most utilitarian objects, and in fulfilment of contracts workmen and equipment have come from Belgium, Czechoslovakia, the Federal Republic of Germany, France, Italy, Norway, the Netherlands, Switzerland, the United Kingdom and the United States.

In addition, thirteen countries undertook to present decorations and fittings for various parts of the buildings. Five of them, Denmark, France, the Federal Republic of Germany, Italy and Switzerland furnished committee rooms each demonstrating artistic trends in their own countries. The modern decor of the executive board room was a gift of the International Council of the Museum of Modern Art of New York made on behalf of the Government and people of the United States. The hall for the international non-governmental organizations was furnished by Czechoslovakia and the Press Room and Library by the Netherlands and Sweden respectively. The offices of the chairman and secretariat of the executive board are a gift of the United Kingdom and the office of the Director General is contributed by Belgium. The equipment and furnishings for the reception office, lobbies and gift-shop have been provided by Canada, Finland and Norway.

From the time the first line was drawn on the draughtsman's board it was recognized that contemporary art should be represented in these buildings. It was also realized that its selection would present considerable difficulties. So an advisory panel of art authorities, supplemented by members of the Architects Committee, was appointed to suggest appropriate artists. The panel consisted of H.E. Mr. C. Parra Perez (Venezuela), Mr. Georges Salles (France), Mr. Shahid Suhrawardy (Pakistan), and Sir Herbert Read (United Kingdom). With an allocation of 191,000 dollars, which had to cover artists'

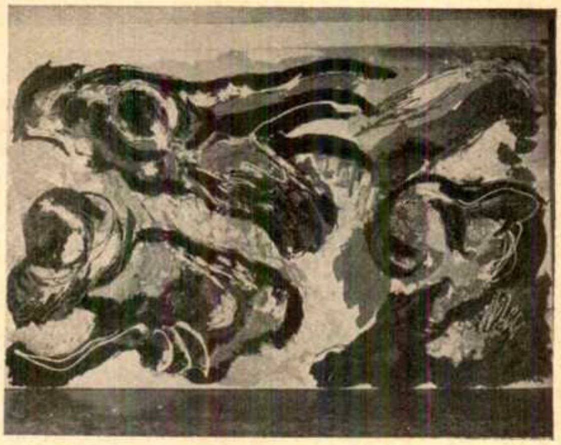


Photo: Unesco–Pablo Volta

Fig. 3. Painting by Appel on the restaurant wall (2·8 m. × 4·2 m.)

there were also several other papers dealing in some detail with each of these aspects.

Radiation Measurement and Dosimetry

Many of the papers concerned with radiation measurement were devoted to the use of gamma spectrometry. From the varied applications of this technique in the control of radiation hazards it is clear that it represents a most important advance. The application of the gamma spectrometric method to the measurement of gamma-radioactivity and beta-radioactivity (by bremsstrahlung) in the human body is now well known, and several papers showed the great value and promise of this technique. A further important application described in a paper from the United States was the use of this technique to measure traces of plutonium contamination in skin wounds and, in certain circumstances, a sensitivity of 4×10^{-5} microcurie of plutonium was attainable. The method offers an immense advantage in that the plutonium can be detected readily at depths in the skin far greater than the range of alpha-particles. The usefulness of the scintillation counting of alpha-activity was shown to good effect in a paper by Prof. W. V. Mayneord from Great Britain reporting direct measurement of the radium and thorium activities occurring naturally in human bone ash.

Progress was also noticeable in the dosimetry of airborne radioactive dust and the decay products of thoron and radon, the monitoring of which has presented considerable difficulties in the past. A paper from the U.S.S.R. by Baranov reported a useful application for health purposes of the $(n,2n)$ activation of carbon with the production of carbon-11 as a means of measuring fast-neutron fluxes in the energy-range exceeding 20 MeV.

Reactor Safety

Two technical sessions were devoted to this topic, on which about twenty-five papers had been contributed; these indicated substantial progress in this important subject. At the first International Conference in 1955 we had a report of experiments on a simple uranium – water reactor which was tested to destruction by power surges. At the present Conference we had reports on the theoretical and experimental investigation of reactor transients in full-scale power reactors. The development of experimental methods in this subject is advancing, so that we shall no longer have to rely so heavily in the future on unsupported calculations concerning safety in reactor kinetics.

Another important aspect of reactor safety in which there seems to be considerable progress is in regard to containment. Apart from reports from Sweden and Norway on novel underground containment for reactors, there appears to be a trend towards very strong compact enclosures which can give a considerable degree of guaranteed containment, and containment designs involving protection against shock-waves and missiles arising from fast-reactor 'runaway' were described from the United States. Indeed, it seems that, when the technology of the design and of the statistical testing of reactor enclosures (possibly on the model scale) has advanced somewhat further, we may well be in a position to tolerate nuclear reactors in heavily populated areas.

Several papers were again concerned with the evaluation of the accidental release of radioactivity from a reactor, and, while for many of the radiological effects the acceptable levels under accident conditions are in reasonable agreement, there appears to be considerable disparity with regard to acceptable emergency exposure of the thyroid; levels of 1,500 and 2,000 rad were suggested in some of the papers, whereas in the accident at Windscale the limiting level of milk contamination actually used corresponds to a thyroid dose of about 10 rad.

Some of the most valuable discussions at Geneva took place in a number of informal sessions in which specialists from several countries were able to meet and have free discussion on some of the more important problems in their particular spheres. One of the great values of the informal sessions was that spontaneous discussion could take place without the necessity for questions to be written down and handed up to the chairman in advance of the discussion period. One such session was devoted to problems of reactor safety, and included, among the introductory talks, one by Academician A. P. Aleksandrov on "Reactor Safety in the U.S.S.R." It was notable that the Russians tended to rely on design of control systems and on remote location rather than on containment to achieve safety, whereas other countries considered provision of satisfactory containment a necessary feature.

A further important informal session was devoted to criticality safety, and included an informal report of experience in a criticality accident at Oak Ridge in June of this year. Although a few persons were exposed to heavy doses of neutron and gamma-radiation ranging up to about 400 rem, the exposures were not lethal. Descriptions of events like this are extremely important in providing lessons for safety in design and operation of criticality facilities and, indeed, of nuclear reactors in general.

The general impression gained from a study of the large number of papers presented on subjects related to health and safety was that substantial progress is being made on many aspects of this important subject. It is considered exceptionally valuable that several countries had thought fit to report frankly their experience on radiation exposure both in regard to workers in their plants and to the environmental hazards of their operations. It is to be hoped that more countries will provide this kind of data in the future. A second important conclusion is that the standard of safety achieved is very high. It seems that the emphasis which has been placed on health and safety in the past has borne fruit, especially in regard to the amount of money which it is now accepted must be devoted to securing an exceptionally high degree of safety in nuclear reactors and plants. A further satisfactory feature of the reports presented at the Conference was the great strides which have been made in the techniques of measurement of radiations, especially for the purpose of health control. On the sensitive subject of radioactive wastes, there appeared to be universal recognition of the principle that the safety of any procedure for the disposal of radioactive materials, whether as liquid effluent or as gaseous activity to the atmosphere (which in the case of the noble gases may be difficult to avoid), must be demonstrated by comprehensive monitoring by the operating agency. This is a principle which might well be extended in other industries.

W. G. Marley

GRAPHITIZATION AND PLASTIC DEFORMATION OF DIAMOND

By DR. M. SEAL

Research Laboratory for the Physics and Chemistry of Solids,
Department of Physics, University of Cambridge

IT is well known that diamond is at normal pressures the thermodynamically unstable form of carbon, and that diamonds heated to a sufficiently high temperature change into graphite. A study has been made of this change, and two important results have been obtained. These are, first, that the change occurs via an intermediate structure of carbon atoms, and secondly, that plastic deformation of diamond can occur at 1,800° C. under the stresses set up by an expanding nucleus of graphitization.

In this investigation two types of diamond specimen were used—a fine powder of 0–1μ particle size, and large single crystals of up to a few millimetres across. The specimens were placed in crucibles of hard pure graphite and were heated in a vacuum of about 10^{-4} mm. mercury in an electric resistance furnace to various temperatures for 15–30 min. The heating was carried out by Dr. D. A. Melford or by Mr. B. L. Mordike of this Laboratory, and I wish to thank these workers for their help.

Experiments with diamond powder gave the following results. Heating to 1,200° C. produced little change and only diamond could afterwards be detected by electron diffraction. Heating to 2,000° C. produced a complete transformation to graphite. For intermediate temperatures of about 1,600° C. both diamond and graphite could afterwards be detected, but electron diffraction patterns also showed spots which were not due to either diamond or graphite. These spots could be indexed for a cubic unit cell, $a = 12{\cdot}3$ A. It is thought that they are due to some sort of intermediate arrangement of carbon atoms, possibly a regular array of diamond-like and graphite-like regions. The existence of such an intermediate structure is of obvious importance to our understanding of the way in which the change occurs. Thus Nath[1] postulated that the puckered {111} planes of carbon atoms of the diamond lattice would become flattened at high temperatures giving the plane hexagonal networks characteristic of graphite: the lattice would also have to expand in a direction perpendicular to these planes to give crystals of graphite which should then be of the rhombohedral type. There is, however, no evidence from the diffraction patterns for an abnormally high percentage of rhombohedral graphite in graphitized diamond, and it is difficult to see how any but a hexagonal intermediate structure could occur in the process that Nath visualized. The occurrence of a cubic intermediate structure must mean that all four {111} planes of the diamond are equally favoured in change. A detailed description of the diffraction patterns which reveal the presence of this intermediate structure will be published elsewhere.

Examination of graphitized diamond powders by transmission electron microscopy using both bright and dark field techniques showed that the graphite forms as crystallites about 100 A. across. These crystallites are formed on or within the individual fragments of the diamond powder which appear to retain their coherence and shape even after the conversion to graphite is complete. The graphite crystallites do not vary significantly in size with temperature of graphitization over the range investigated (1,400–2,000° C.), but they are, of course, more numerous for the higher temperatures.

With large single crystals the sequence of changes described in Table 1 was observed visually after graphitization.

Table 1

Temperature of graphitization	Appearance
1,200° C.	Slight dulling of surface
1,400° C.	Definite grey colour
1,500° C.	Diamond appears dark grey but still translucent
1,800° C.	Diamond black, opaque and starting to break up
2,000° C.	Small black fragments

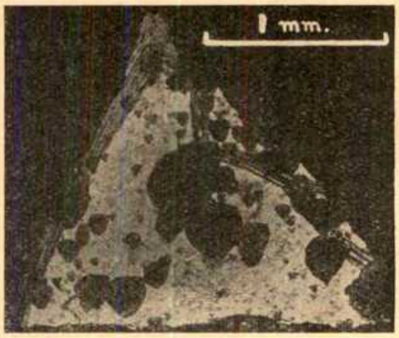


Fig. 1. Optical micrograph of a natural {111} diamond face after graphitization at 1,800° C.

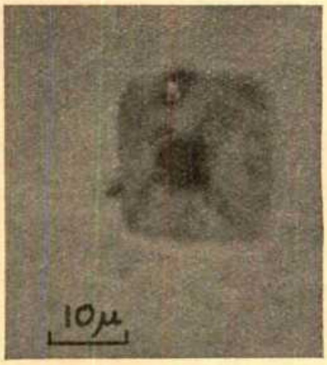


Fig. 2. Optical micrograph of a feature produced on a polished {100} diamond face by heating to 1,800° C.

Fig. 3

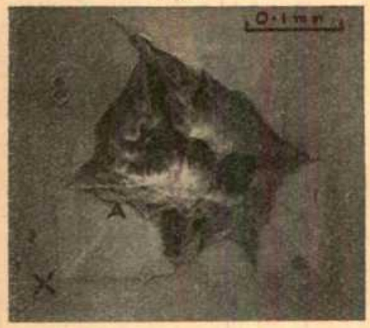
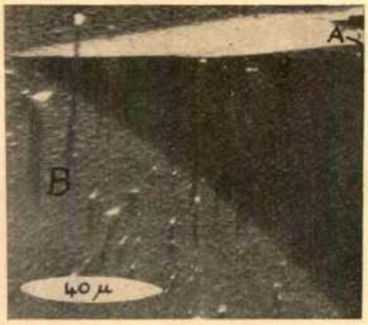


Fig. 4



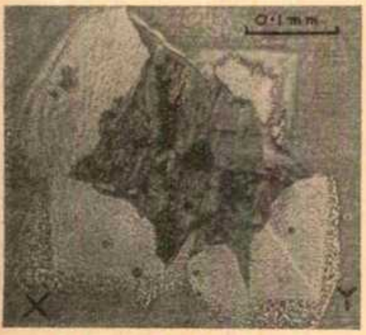


Fig. 6

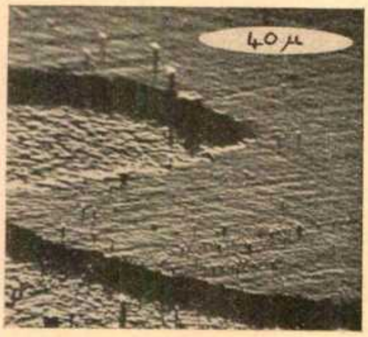


Fig. 5

Fig. 3. Phase-contrast optical micrograph of a large feature produced on a polished {100} diamond face by heating to 1,800° C.

Fig. 4. Reflexion electron micrograph of the limb *X* of the feature appearing in Fig. 3

Fig. 5. Reflexion electron micrograph of part of a {100} polished diamond surface after graphitization at 1,800° C. and abrasion with alumina. The surface graphite layer has been removed in places by the alumina

Fig. 6. Phase contrast optical micrograph of the feature of Fig. 3 after abrasion with alumina

These changes are similar to those described by previous workers[2,3]. Examination of the surfaces with an optical microscope showed no apparent change in the microstructure for graphitization at temperatures below 1,500° C. However, between 1,500° C. and the break up at about 1,800° C. marked changes in the surface topography did occur. Fourteen faces on eight diamonds graphitized at temperatures in this range have been examined. The features produced by the heat treatment on these faces were substantially similar, though at different stages of development. On three faces (two natural octahedral {111}, and one polished cube {100}), the features were particularly regular and well defined. These faces have been studied in detail, since they provide most information about the way in which graphitization occurs.

One of the natural octahedron faces is shown in Fig. 1: this had been graphitized at 1,800° C. The face is covered with dark patches which, though sometimes rather irregular in outline, do show a tendency to have a triangular shape. Examination at higher magnification revealed the presence of numerous similar but smaller triangular features. The surface relief was investigated using reflexion electron microscopy and it was shown that the triangles, etc., represent raised regions: the more regular of them are pyramidal in shape. The triangles are oriented with their sides parallel to the edges of the face, but they point in the opposite direction to the face. The polished cube face after graphitization at 1,800° C. showed similar features, but in this case they are square in outline and more regular in shape. An example is shown in Fig. 2. The features are again raised pyramids, and each has a central dark spot which represents a more sharply raised region. They have a wide variation in size, ranging from the limit of resolution of the optical microscope up to 0·3 mm. across for one particularly large composite feature (shown in Fig. 3). In each case where the height was measured it was found to be of the order of one tenth of the width of the feature. The squares are oriented, in some cases parallel to the crystallographic axes and in others at 45° to them. It can be seen that the large composite feature of Fig. 3 has three V-shaped limbs. These are portions of pyramids sloping upwards towards the irregular central region. Fig. 4 is a reflexion electron micrograph of one of these limbs (*X* of Fig. 3). The height of the point *A* above the general level of the surface is 4μ; the irregular central region is considerably higher.

The graphitized diamond on which the features shown in Figs. 2 to 4 appeared retained its original shape but became black and opaque after the heat treatment. It seemed likely that the graphite had formed as a surface layer (cf. Friedel and Ribaud[2]). To test whether or not this was so, the graphitized diamond was rubbed with a paste of water and fine alumina on a soft cloth. It was found that this treatment removed a surface film and that the underlying material was colourless and transparent—in fact, diamond. It was possible to estimate the thickness of the surface graphite layer in the following way. The abrasion with alumina removed the surface graphite layer in patches. The change in height at the edges of these patches was quite sharp, and it seemed that the abrasive had removed the surface layer by some sort of flaking process in which the entire thickness of the layer came away. A reflexion electron micrograph of a region at the edge of one of the patches is shown in Fig. 5. The thickness of the graphite layer could easily be measured from the length of the shadows cast by its edge. The abrasion grooves which were present on the original polished diamond surface before graphitization could also be seen after graphitization, both before and after the abrasion with alumina. Thus, the thickness of any layer removed from the top of the graphite layer by the abrasion with alumina was less than the depth of these grooves. For the film on the (100) surface which is being described, this was not more than 0·1μ. The remaining film, as seen in Fig. 5, was 0·5μ thick, and so the total original thickness of the graphite surface layer could be given as 0·6 ± 0·1μ.

The effect of the abrasion with alumina on the large feature of Fig. 3 is shown in Fig. 6. The rougher regions where the surface graphite layer has been removed can be seen by comparison of Figs. 3 and 6. Examination of the surface by optical microscopy using illumination from behind showed that these rougher regions were transparent and that the central feature was opaque and spread slightly sideways

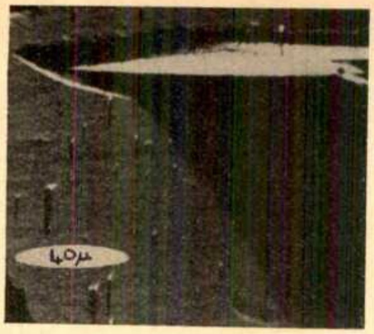
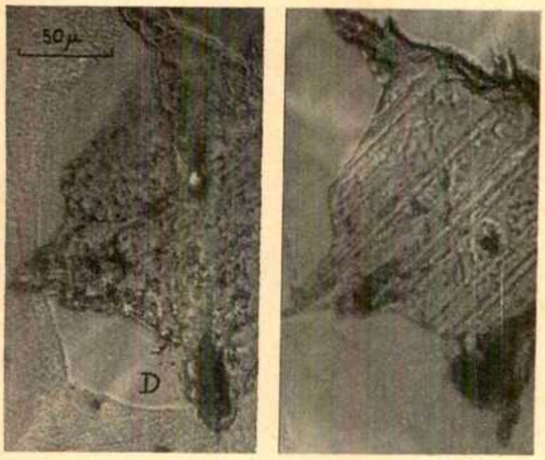


Fig. 7. Reflexion electron micrograph of the limb *Y* of Fig. 6

beneath the surface of the diamond. The V-shaped limbs were still present and could be seen to consist of transparent material. Reflexion electron microscopy (Fig. 7) and optical multiple-beam interferometry showed that they were still pyramidal in shape. The ridge of the limb *X* was found to have a slope of $2 \cdot 4° \pm 0 \cdot 1°$ and the point *A* to be $4 \cdot 2 \pm 0 \cdot 4\mu$ above the level of the original flat graphite surface (the level of the region *B* of Fig. 4). It follows that diamond has been transported to a position above the original level of the diamond surface. The only ways in which this can have happened are through plastic or elastic deformation of the diamond.

It does not seem to be possible to explain this transport of material in terms of elastic deformation of the diamond. The change in slope at the base of the pyramids is extremely sharp (Fig. 7), and it can easily be shown that the stresses necessary to produce so sudden a bending elastically would be impossibly big. One would, therefore, have to suppose that the stresses were relieved by cracking. This would have to be on such a scale that it should be readily visible. In fact, no evidence of such cracking could be observed even after the surface layers had been removed by polishing on an abrasive diamond wheel. Optical examination following this polishing did, however, give a confirmation of the nature of the feature. Fig. 8*a* was taken after the top of the feature had been polished away; the tops of the truncated pyramidal limbs (such as *D*) appear smooth and homogeneous in contrast to the rougher central region. Fig. 8*b* was taken after further polishing and represents a section of the feature a few microns below the original level of the surface: the region under the pyramidal limbs is indistinguishable from the surrounding diamond. It is concluded that the central region which is opaque and almost certainly graphite represents a nucleus of graphitization and that this, owing to the difference in densities, has expanded, forcing the surrounding diamond to deform plastically.



(*a*) (*b*)

Fig. 8. Phase-contrast optical micrographs of part of the feature of Fig. 6 after high-speed abrasion with diamond powder: (*a*) the top of the feature only has been removed; (*b*) abrasion has been continued and the surface seen here is a section through the feature a few microns below the original surface of the diamond

There is thus strong evidence which suggests that plastic deformation of diamond can occur at a sufficient temperature. This observation is of considerable interest since diamond is at normal temperatures a very brittle solid and all attempts to produce plastic deformation of it in the cold have met with at best doubtful success. There are, however, previous reports of plastic deformation being produced in this material at high temperature. Friedel and Ribaud[3] reported a relaxation of birefringence in a diamond heated to 1,880° C.: they interpreted this as indicating that plastic deformation had occurred. Evidence that plastic deformation can occur during the polishing of diamond was found by Seal and Menter[4]. Diamond is normally polished with diamond dust on a high-speed lap, and the conditions of abrasion are such that local frictional 'hot-spots' of 1,000° C. or more are almost certainly produced. Thus, high temperatures would again be involved in the plastic deformation. There is also evidence[5,6] that slip has occurred in some natural diamonds at some time during their geological history—very probably at high temperatures.

The particularly large feature which has been described was chosen for detailed study because of its size. The smaller features do, however, appear to be similar to it, and it is inferred that they are of the same nature. The experiments in which the surface layers of the diamond were polished away showed that these smaller features extend into the diamond to a depth comparable with their width in the surface. Thus, it is thought that all the raised square features seen on the {100} face and the triangular ones on the {111} faces represent nuclei of graphitization. These nuclei only occur near the surface of a diamond crystal and not within the bulk of the diamond.

The reason for this may perhaps be found from the following considerations. One may suppose that an incipient nucleus of graphite has formed within the bulk of a comparatively large mass of diamond. The nucleus originated in a smaller volume of diamond: it is therefore under compression from the surrounding diamond and occupies a smaller volume than it would otherwise have done. The diamond is in its turn under stress. The pressure within the nucleus can be calculated if simplifying assumptions are made. It is assumed that the nucleus is spherical, that it and the material surrounding it are both isotropic, and that the deformations are entirely elastic. The problem then becomes an elementary application of the laws of elasticity and the pressure is found to depend only on the compressibilities and densities of diamond and graphite and not on the radius of the nucleus. The numerical values of the compressibilities and densities at 1,800° C. are not known, but if the room-temperature values of these quantities are used then the pressure is found to be of the order of 10^5 atmospheres. Such a pressure would probably be sufficient to make diamond the thermodynamically stable form of carbon. Thus the nucleation of graphite will not occur within the bulk of the diamond since the pressure produced in an incipient nucleus will be sufficient to inhibit the transformation. There is experimental evidence that pressures of the order of 10^4 atmospheres are sufficient to inhibit the transformation of diamond to graphite even though diamond is still thermodynamically unstable[7].

These considerations no longer apply, of course, at the surface of the diamond, and graphitization would be expected to proceed inwards from the surface, as is in fact observed. Moreover, an incipient nucleus just below the surface (forming perhaps at a dislocation or other fault in the diamond) might expand suddenly and burst through the thin shell of diamond above it. This is thought to be the explanation of the raised features which have been described. They are, as it were, miniature volcanoes which have burst through the surface of the hot diamond and forced it to deform plastically.

I wish to thank Dr. F. P. Bowden for his interest and advice, and Industrial Distributors (1946), Ltd., for a grant to the Laboratory.

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TYPHOON EFFECTS AT JALUIT ATOLL IN THE MARSHALL ISLANDS

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ON January 7, 1958, a small, very intense typhoon passed directly over Jaluit Atoll in the Marshall Islands (5½° N., 169½° E.). The first reports thereafter indicated that the typhoon had wrought many profound changes, especially in its effects upon the morphology of several of the islets and upon the vegetation and soils. Accordingly, the Pacific Science Board of the U.S. National Academy of Sciences, acting together with the Office of Naval Research and the U.S. Trust Territory of the Pacific, sponsored the formation of a party of seven scientists to conduct a brief, but intensive, field study at Jaluit. In addition to myself, the field party included Dr. A. H. Banner, director of the Marine Biological Laboratory, University of Hawaii; Dr. F. R. Fosberg, Pacific Vegetation Project, U.S. Geological Survey; Dr. J. Linsley Gressitt, chairman, Entomology Department, Bishop Museum; Dr. Edwin D. McKee, geologist, U.S. Geological Survey; Dr. Herold J. Wiens, professor of geography, Yale University; and Mr. J. B. Mackenzie, who has been director of the Agricultural Experiment Station maintained at Jaluit by the U.S. Trust Territory of the Pacific during the past several years. It is the purpose of this article to report very briefly and in a preliminary sense on the principal findings of this field party, which studied conditions on several different islets of Jaluit during April 24–May 2.

The Typhoon

Because of the paucity of weather observations over the ocean to eastward, the storm that struck Jaluit was not known to be of typhoon intensity before it struck. It was, however, being carried as a storm that had appeared at Palmyra Island (5° 53′ N., 162° 5′ W.) and was approaching Jaluit from the east. After striking Jaluit, the storm moved on a west-north-west heading through the Marshall and Caroline Islands and into the Philippine Sea, where it died out. Among the islands seriously afflicted by the storm were Ponape, Truk, and the Hall Islands, all in the Caroline Islands. When the typhoon intensity of the storm was first established it was named 'Ophelia'; and that name will be used here.

At Jaluit, judging from eye-witness accounts and from the field evidence, 'Ophelia' produced winds with sustained speeds of at least 125 knots and brought ahead of it and with it pronounced storm tides on which large wind waves were superimposed. Strong winds came initially from the north-east quadrant, then backed through west to south. There was at least one distinct lull, indicating that the eye of the storm crossed the atoll. There was initially a series of wave surges from the east, and these inundated several of the islets along the eastern reef, in one instance to a depth of 6 ft. above the ground in a locality that is more than 8 ft. above mean sea level. These first inundations occurred between late morning and mid-afternoon (180th meridian time) and were quite promptly followed by much lesser inundations upon the islets along the western rim, the wave having been renewed within the lagoon, which is about 15 miles wide (from east to west) and 30 miles long (from north-north-west to south-south-east). Later, in the afternoon or early evening, there was further, but only partial, inundation from waves moving eastward in the lagoon and waves moving south-eastward over the ocean to the west of the atoll. By dawn on January 8 the storm had subsided and the wind had become easterly, the normal trade-wind direction.

Geomorphic Changes

The observations of McKee and Wiens in particular, but also those of the other members of the party, led to the identification of several new geomorphic features, especially on those islets that suffered major inundations. These include depositional and erosional forms.

The chief depositional forms produced by the storm were locally prominent gravel ridges upon the reef flat on the ocean side of some of the eastern islets; new or augmented beach ridges of gravel; gravel sheets, often tongue-shaped, extending across two-thirds of the islets in many places; and outwash features on the lagoon-side of the eastern islets. These lagoon-side sediments were strewn upon the reef and beyond into deeper water, as was shown by bottom samples obtained by Banner and McKee. They also may have helped form the gravel bars observed in some locations on the lagoon-side, both on the reef flat and beyond, though these bars also contain sediments derived from the floor of the open lagoon itself.

The most prominent erosion feature was the channels scoured out by the water. The best-developed ones originated at a break in the old beach ridge on the ocean-side of the eastern islets and extended several hundred yards across to the lagoon-side, where they gave rise to pronounced outwash features. Minor erosion features include plunge holes and scour pits.

Soils

On those eastern islets that were awash, the soils existing prior to the storm were either buried or scoured out over wide areas. On the islet of Mejatto, for example, more than half of the pre-existing soil now lies beneath a sheet of coral rubble that is from 5–6 in. to 2½ ft. thick. Severe scouring has sluiced off about one-fourth of the soil. The remaining 15–25 per cent is either partially eroded or else persists with little or no change, except, perhaps, in salinity.

A discovery made by McKee and Fosberg may prove to be of special interest. In a well cross-section, at a depth of about 3 ft., they found an undisturbed soil profile overlain by coral rubble to provide a disconformity that is precisely analogous to that produced by 'Ophelia'. This suggests that it might be possible to date, by the carbon-14 technique, those typhoons in past centuries that were sufficiently intense and sufficiently 'on target' to yield gravel sheets upon atolls anywhere.

Vegetation

The principal broad-scale effects of the storm upon the vegetation is well summed up by Fosberg in the introductory portion of his report (now in manuscript). His remarks should be viewed in the light of the fact that prior to the storm Jaluit was densely vegetated, since it lies in an area where the rainfall averages close to 200 in. a year.

"The effects of Typhoon 'Ophelia', even on the same vegetation type, or on the same plant, were by no means identical in all localities and parts of the atoll. In general, the islets on the eastside of the atoll suffered much more damage to their vegetation than those on north, south, and west. Also . . . narrow islets and parts of islets were far more affected than broad parts. This was well illustrated on Jaluit Islet, where the narrow parts south of Jabor were in places completely stripped of vegetation. . . .

"Many trees were uprooted. . . . Some were snapped off. Branches were broken or torn off of most of those that remained standing. Some exotic plants were killed or their above ground parts killed by salt. In places large scale burial of plants by gravel occurred. Elsewhere the soil with its vegetation was scoured away. Many tree trunks were seen in the lagoon on the shallower slopes along the east side. Masses of vegetable debris were strewn at random on the shallower slopes along the east side."

From the observations of Fosberg, Wiens and Blumenstock it is estimated that among those islets studied the greatest destruction was on Mejatto and northern Jaluit, both islets on the eastern reef, where 70–90 per cent of the trees were either completely uprooted or snapped off below the crown; while the least destruction was on western islets, where only 20–50 per cent were uprooted or snapped off. As for the comparative resistance of different tree species to the wind, Fosberg observes that *Pemphis*, *Cordia*, *Calophyllum*, *Casuarina* and *Bruguiera* "perhaps stood up best", while *Pandanus*, breadfruit and *Terminalia catappa* "perhaps fared worst".

Terrestrial Fauna

Gressitt observed that there was no evidence that the storm had eliminated any terrestrial faunal species. There were, however, pronounced effects upon populations and breeding-rates, with local extinction where vegetation was eliminated. He states: "Groups which seem to have suffered most appear to be rats, soil insects, grasshoppers, and scale insects. The birds (sea and shore birds, dove, cuckoo), lizards (geckos, skinks), brackish water shrimps, amphipods, land crabs, and spiders seem to have suffered very little. . . . *Culex* mosquitoes are breeding abundantly in cisterns which were inundated by sea water. House-flies and other filth flies are breeding abundantly, partly in privies as usual, and partly in some of the piles of accumulated decaying vegetation. Other insects found in the latter habitat, and under bark of dead trees, are breeding up large populations because of increase in their habitat as a result of the extensive killing and felling of trees and other plants. Still other insects, mainly moths and hemipterans, are breeding up large populations on new growth, apparently as a result of greater mortality among their parasites".

Submarine Features and Marine Life

Banner examined the submarine conditions within the lagoon by diving to depths of 30 ft. and more in many different places. He also examined depositional materials on newly formed bars and upon the islets, with special reference to its probable derivation. It was not possible, however, to observe the submarine features along the reef front in the surge channel zone because of heavy surf conditions.

On the bottom of the lagoon below low low-tide there was no evidence of disturbed conditions. Even delicate corals were not broken. In contrast, it seems likely that the outer reef front suffered pronounced changes, at least in some sections, because more than 75 per cent of the coral rubble forming the new ocean-side bar off Jaluit Islet is comprised of materials newly wrested from the outer reef.

The storm seems to have had no great effect upon the fish life in the lagoon. The inhabitants report better fishing since the storm than there was before; but it is possible that they gain this impression through having to fish more intensively than before, since vegetable food is in short supply.

Demography and Cultural Effects

Fourteen Marshallese died in the storm. Two more died of exhaustion immediately thereafter. This toll was surprisingly light considering the fact that there were some 1,200 inhabitants living on the atoll when the storm struck.

The low fatality-rate was the result of three factors. Imroj, the most densely populated islet, was not completely under water. Further, about 150 natives of Mejatto happened to be visiting Imroj for a social event when the storm waves swept their islet. And the natives on Jaluit Islet were able to take refuge in sturdy Japanese, cement-block buildings that were the only structures to withstand the storm.

On islets not under water, nearly all habitations were destroyed. Buildings made of board and corrugated iron blew apart. Native buildings, of grass, fibre and pandanus, blew down; but according to informants these were readily pushed back up, reinforced, and thus re-established after the storm.

Many of the inhabitants on the eastern, inundated islets have been forced to move to Imroj. Already, however, a few are beginning to move back home. Great quantities of supplementary food are being supplied by the U.S. Trust Territory Government, and these supplies will have to continue for a long time. Though replanting is taking place and though new vegetation is sprouting from vegetative debris, it will doubtless be at least a decade before the atoll has really recovered. Meanwhile, it is planned to re-study the atoll at intervals to learn how an atoll recovers from a typhoon strike.

FLUORINE COMPOUNDS

At the recent meeting of the British Association in Glasgow, one of the sessions in Section *B* (Chemistry), on September 2, was devoted to various aspects of the chemistry of fluorine compounds. Dr. J. Craik presided during the first part of the meeting, and Prof. R. A. Raphael for the latter part.

The first paper, given by Dr. J. C. Tatlow (University of Birmingham) was entitled "Fluorocarbons: a New Branch of Organic Chemistry". As a result of investigations during the past twenty-five years, it is now apparent that there exists a new type of organic chemistry, based upon the carbon–fluorine system, and paralleling the carbon–hydrogen system of ordinary organic chemistry. Thus, analogous to the saturated hydrocarbons, there are the fluorocarbons. Many open-chain and alicyclic compounds of this type are now known, with up to thirty or more carbon atoms. Fluorine can form the basis for this new branch of organic chemistry because the bond between a carbon and a fluorine atom is an extremely stable one, and also because the size of a fluorine atom is not too great to allow saturated fluorocarbon chains [$CF_3.(CF_2)_n.CF_3$] to exist without strain. If the atoms were very much larger, there would be insufficient room for enough of them to be carried on a carbon skeleton. However, fluorine atoms are bigger than hydrogens, and in a fluorocarbon they shield the backbone of carbon atoms, and thereby protect them from attack by chemical reagents, much more effectively than is the case with hydrogen substituents in hydrocarbons. Thus, two factors contribute to the great stability of fluorocarbons which are among the most unreactive organic compounds known. They are non-inflammable and are resistant to attack by acids, alkalis, oxidizing agents, and reducing agents.

As in orthodox organic chemistry, a vast range of compounds based on this parent series is capable of existence, since various other atoms and functional groups can be substituted in the molecules. Such derivatives are rarely prepared from fluorocarbons themselves (because of the great stability mentioned above they will seldom take part in controlled reactions). However, very many classes of fluorocarbon derivatives containing a variety of functional groups can be made in other ways. Simple examples of types now freely available are fluorocarbon carboxylic acids (for example $CF_3.CO_2H$), sulphonic acids (for example, $CF_3.SO_3H$), alcohols (for example, $CF_3.CH_2OH$), and amines (for example, $CF_3.CH_2NH_2$; compounds containing the groups $—CF_2.OH$ and $—CF_2.NH_2$ are not known). In all cases a complete homologous series can be made. The fluorocarbon part of the molecule can modify considerably the properties usually conferred on an organic compound by the functional group. Thus, the acids $CF_3.CO_2H$ and $CF_3.SO_3H$ are very much stronger than their analogues containing CH_3-groups. Usually, however, the fluorocarbon residue retains its inertness to chemical attack. Hydrogen and the other halogens can accompany fluorine as substituents on a carbon skeleton, and again various functional groups can be present as well, so that vast numbers of fluorine compounds are potentially capable of existence.

Recently, routes to perfluoro-aromatic compounds such as hexafluorobenzene have been opened up, and this most interesting new section of fluorocarbon chemistry is being investigated actively at present.

Because of their general stability, organic fluorine compounds are becoming increasingly important industrially as specialist materials. One typical example is in chromium plating, where long-chain fluorocarbon sulphonic acids (for example, $C_{10}F_{21}.SO_3H$), which are surface-active, can be employed to reduce spray above the plating baths. These use hot chromic acid, which attacks and destroys hydrocarbon-based detergents.

Fluoro-polymers are finding ever increasing applications. Recently, a series of rubbers has been introduced which are very stable towards heat and chemical reagents.

Mr. H. R. Leech (Research Department, I.C.I. General Chemicals Division) spoke next on "The Industrial Advance of Fluorine". A generation ago, fluorine was an 'awkward' element. The compounds in which it occurred naturally were inert and insoluble, but when they were brought into chemical usage, great difficulty was experienced in handling hydrogen fluoride and the element itself. This situation has now been changed completely, however. It is not always realized that fluorides are quite widespread in Nature, the element being thirteenth in order of abundance in the Earth's crust—more abundant than chlorine. Anhydrous hydrogen fluoride is now an important article of commerce and is made on a considerable scale from fluorspar and concentrated sulphuric acid. Handling it involves no great difficulties if the right equipment and techniques are used, and it may be transported in cylinders and tank cars. The same applies to fluorine itself.

One of the most important routes to organic fluorine compounds is by halogen exchange. The fluorine of hydrogen fluoride or a metallic fluoride is exchanged for another halogen in an organic structure. In this way, a range of simple fluoro-chloro-aliphatic compounds can be made. Compounds such as dichlorodifluoromethane have found wide application as refrigerants and as aerosol propellants. They are made in large quantities and are marketed under the trade names 'Freons', 'Arctons' and 'Isceons'. From compounds of this type, by simple reactions, the olefins tetrafluoroethylene and chlorotrifluoroethylene are obtained. These may be polymerized to give the fluoro-polymers, 'Teflon' or 'Fluon', and 'Kel-F', respectively. The first of these, particularly, has remarkable properties, being non-inflammable, and chemically stable. Also, it has valuable 'low friction' and 'non-stick' characteristics; one use arising from the last is for coating rollers which handle dough in bakeries. Polymers such as these are finding ever wider applications in many fields. Another valuable product of this halogen-exchange method of fluorination is the new non-inflammable anæsthetic 'Fluothane' ($CF_3.CHClBr$) recently made available by Imperial Chemical Industries.

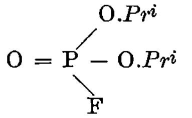
A second route to fluorine compounds is through the element itself. The preparation of fluorine by electrolysis of anhydrous hydrogen fluorine–potassium fluoride systems is now a routine operation and considerable quantities are used in the field of atomic energy. The preparations of chlorine trifluoride, sulphur hexafluoride, and uranium hexafluoride are carried out via elementary fluorine.

In the organic field, though much laboratory work has been done on fluorinations with the element itself, the reactions are difficult to apply on a larger scale and there has been little industrial development of this sort. The same is true of fluorinations involving high-valency transition metal fluorides such as cobaltic fluoride, though this is a valuable research method.

The electrochemical method of fluorination is potentially very useful, however. The organic compound to be fluorinated is dissolved in anhydrous hydrogen fluoride and electrolysed at voltages below those necessary for the liberation of free fluorine. Many functional groups are left intact in this process so that various types of fluorocarbon derivatives can be prepared in this way. Examples are fluorocarbon carboxylic acids, sulphonic acids, ethers and tertiary amines.

The development of the chemistry of fluorine is likely to see many further advances, and new kinds of compounds are constantly being made available and their potential value explored.

Dr. B. C. Saunders (University of Cambridge) presented a paper entitled "Physiological Properties of Toxic Organic Compounds containing Fluorine". He gave a most entertaining account, including some personal reminiscences of his own work. First, toxic fluorine compounds containing P—F linkages were described. Compounds of this type were first reported by Dr. Saunders and his colleagues in 1941. One of the most interesting was di-*iso*propylphosphorofluoridate:



$$O = P(O.Pr^i)_2F$$

and since then many similar compounds have been made. Tests carried out on the investigators themselves showed that exposure to low concentrations of the vapours of these compounds caused constriction of the pupil of the eye (myosis), powers of accommodation being affected and photophobia and intense headaches being experienced. Higher concentrations (tested on small animals) caused a quick knock-out action, the symptoms being muscular weakness, gasping, and finally cessation of respiration. The compounds are toxic by injection as well as by inhalation.

All these effects can be explained on the basis of interference with the enzyme cholinesterase, which is intimately concerned with the propagation of certain nerve impulses—hence the names nerve gases and anticholinesterases given to this class of compounds.

Dr. Saunders gave a brief account of the mammalian nervous system, and described how, when the acetylcholine liberated at the ends of the parasympathetic nerve fibres has performed its job by causing the appropriate physiological response, it is normally destroyed by being hydrolysed, by the enzyme cholinesterase, to choline and acetic acid. The nerve gas inhibits the action of cholinesterase and so allows acetylcholine to accumulate. This inhibition may be caused by the formation of a hydrogen bond between a hydrogen atom of the enzyme and a fluorine atom, followed by attachment of the phosphorus to a basic group of the enzyme.

These toxic compounds have found applications as 'systemic' insecticides which are absorbed by the plant and then transferred to other parts, so that any insects attacking the plant are killed. To be of use such compounds should be of negligible toxicity towards mammals and also should be broken down at such rates as to be entirely innocuous when the crops are harvested.

A second and most important group of toxic fluorine compounds is a series related to monofluoroacetic acid. Here, there is a C—F link, but with one such bond only in the molecule. These compounds are convulsant poisons. Comparable toxicities are shown by fluoroacetic acid, its salts, esters, and simple derivatives, whereas di- and tri-fluoroacetic acid and their derivatives are inactive. In general, most compounds that can be hydrolysed or oxidized in the animal body to fluoroacetic acid are toxic (fluoroethanol has properties identical with those of the acid). This applies also to derivatives of longer-chain ω-fluoroacids, $F(CH_2)_n.CO_2R$, where n is odd, though if n is even the compounds are non-toxic. It has long been thought that fatty acids are oxidized in the animal body by loss of two carbon atoms at a time, owing to oxidation at the carbon atom β to the original carboxyl group, and the toxic properties of the long-chain ω-fluorocarboxylic acids afford a striking proof of this theory. If the carbon skeleton of a toxic long-chain acid is modified so that β-oxidation cannot take place, the compound is devoid of toxic properties.

The reason for the toxicity of the compounds related to fluoroacetic acid is that they interfere in the Krebs tricarboxylic acid cycle. The body does not distinguish between acetic acid and its derivative with one fluorine substituent in place of a hydrogen, and fluoroacetate is built up into fluorocitric acid, causing a jamming of the normal tricarboxylic acid cycle.

The South African plant gifblaar contains sodium fluoroacetate and is extremely poisonous. It seems to grow best where the water has a high fluorine content. The enzymes involved in this synthesis of fluoroacetate are not yet known.

Dr. Saunders concluded by speculating as to whether other living systems, for example, green algae or even the animal body, by some 'deranged' mechanism might possibly synthesize organic fluorine compounds from inorganic fluorides. Some of these might be deleterious (for example, fluoroacetate), some beneficial (*cf.* recent reports of potent synthetic fluorine-containing analogues of steroid hormones).

The last paper, "Fluorine and Dental Decay, Fifty Years of Research", was by Dr. J. Campbell (Glasgow Dental Hospital). He emphasized that dental decay is the most prevalent human disease and is increasing at a rate which outstrips the capacity of the dental profession to deal with it. Some possible preventive measures, for example, reducing the consumption of sugar, are impossible to apply because of lack of public support. Fluoridation of domestic water supplies, however, will reduce dental caries by 60 per cent and has been recommended by the World Health Organization. Regarding the speculation raised by Dr. Saunders, Dr. Campbell pointed out that fluorine is in all of us, anyway, and is a normal constituent of human teeth. Many natural water supplies contain fluoride ion in relatively large quantities, much more than would be introduced by fluoridation.

Fifty years ago dentists noticed that children in certain districts of the Rocky Mountains had mottled teeth but were considerably less susceptible than other children to dental decay. They suspected a constituent of the water, and later, fluoride ion was identified as the responsible agent. Subsequent work showed that a fluoride ion content of about 1 p.p.m. would give a considerable degree of immunity to dental decay without discolouring the teeth. Such discolouring occurred only if the concentration was considerably higher. Various examples of the effects on dental health of high and low concentrations of fluoride ion in natural waters in North America and in Britain were quoted, including the cases of the children from North and South Shields. During the wartime evacuations it was found that the teeth of the children from South Shields were better than those of the children from North Shields and it was shown that the water supply in South Shields contains the optimum concentration of fluoride ion while that of North Shields is deficient. The advantages of artificial fluoridation of the water supplies of towns where the fluoride content is deficient are thus apparent. Intensive investigations have shown that artificially fluoridated water is identical with water that has been fluoridated by Nature, and that no industrial or other processes would be harmed by the addition of such small traces of fluoride ion. Water engineers are able to guarantee the accuracy and the uniformity of the additions of fluoride ion. Artificial fluoridation was first started thirteen years ago in certain towns in the United States and Canada, and has been completely successful. Dental decay has dropped by some 60 per cent and general health standards have been maintained. Fluoridation is now widely practised in North America (some 34 million people there are now receiving fluoridated water). It was started about two years ago in Britain on a very limited scale. All the results so far have been in accordance with expectation.

In conclusion, Prof. Raphael said that the issue of whether or not the fluoridation of water supplies should be carried out must be judged on the scientific facts which are now well established.

J. C. Tatlow

THE GEOLOGISTS' ASSOCIATION

A CENTENARY

By Prof. DAVID WILLIAMS
Imperial College of Science and Technology, London

Since its inception in 1858, when a few ardent amateur geologists met at No. 2 Upper Wellington Street, Strand, London, "modestly to seek mutual help as learners", the Geologists' Association has attracted recruits from all walks of life, from the veriest tyro to the savant steeped in geological lore, until now its membership is 2,032. The Association was opportunely born at a time when geology had so captured the imagination of the layman that the original prospectus could rightly claim that "There is no branch of Science which attracts so general—it may be said so popular—an interest as Geology". Only six weeks after the founding of an Association had first been mooted, nearly two hundred enthusiasts heard an inaugural address on "The Finding of True Facts".

Among the original objects and aims of the Association were the reading and discussion of papers, the exhibition of specimens, the dissemination of geological knowledge by printed *Proceedings*, and the holding of excursions. All these laudable aims have remained inviolate, though none has achieved such paramount importance as the excursions or field-meetings. Indeed, the longevity and continued prosperity of the Association is due in large measure to the genial companionship and mutual encouragement of its amateur and professional members, engendered and nurtured among hills and dales, mountain crags and lowland plains. Characteristically, to mark its centenary year, the Association held a series of field-meetings, ranging from Land's End to John o' Groats, besides which a wide range of geological guide books is being issued dealing with classic areas, the coasts of Britain and the environs of university cities in Britain.

By 1908, the jubilee year of the Association, the membership had risen to 661, by 1925 the total had reached 1,000, and in 1951 the 2,000 mark was passed for the first time. Candidates, irrespective of age or sex, have always been welcomed to membership, and many a novice has thus been inspired by the Association to become an eager disciple and exponent of geology. With few exceptions the present rules differ but slightly from those of a hundred years ago. The prospectus of 1858 stated that "the subscriptions have purposely, and with deliberate consideration, been fixed at a rate which will exclude none from the benefits it can give". Indeed, it is quite remarkable that not until 1952 was the Association compelled, by the fall in the value of money and the increased cost of publishing its *Proceedings*, to raise the annual subscription from 10*s*. to £1.

Unlike many other scientific societies, the Geologists' Association has never had a home or headquarters of its own; thanks to the kindness and generosity of various bodies and institutions, however, it has always been able to hold regular monthly meetings for the presentation of papers and the delivery of lectures. During the first few years these were held at St. Martin's Hall, Long Acre, at the College of Dentists and at the Medical Society of London; but from 1867 until 1939 the Association received spacious hospitality from University College, London, and since then it has enjoyed the privilege of meeting in the dignified rooms of its 'senior partner', the Geological Society of London.

In 1922, the Council sanctioned the formation of Local Groups, especially in areas where members were not within easy reach of ordinary meetings and field-meetings around London. The first to be formed was the North-East Lancashire Group in 1922; this was followed by the St Helen's District Group in 1929 (now defunct), the Midland Group in 1937, the North Staffordshire Group in 1949, and by the Jamaica Group in 1955. Incidentally, as part of the centennial celebrations, the Jamaica Group is erecting in the island, at Halse Hall, Kingston, a memorial plaque in honour of Sir Henry de la Beche, the first director of the Geological Survey of Great Britain, who lived there as a child and again in 1823–24.

In 1923, a Weald Research Committee was formed for the purpose of making a complete survey of the whole of the country involved in the anticlinal structure of the Weald; it has published a long series of original papers and reports of field-meetings, numbering almost a hundred in all. For several years during the 1920's, a Temporary Sections Committee organized the collection of records of transient sections, such as road excavations and building foundations, in the metropolitan area, a task which has been successfully continued by the London Naturalists' Society.

The Association is indebted to many of its members, both past and present, for generous bequests, some of which exist in the form of special funds or awards—as the Foulerton Award Fund, the Henry Stopes Memorial Fund, and the G. W. Young Investigation Fund.

Papers submitted for reading at ordinary meetings have steadily increased in number, while their diversity and standard arouse widespread commendation in geological circles. The first annual conversazione appears to have been held in 1863; during the long sojourn at University College the conversaziones attracted large gatherings to the main library and in later years to the Great Hall. Following a war-time interruption from 1939 to 1941 this popular function, thereafter named the annual reunion, has been held early in November at various institutions, usually at the Chelsea Polytechnic. During the present century the attendance has seldom been less than 50, and has sometimes reached 350.

One-day excursions, which started in 1860 on quite a small scale, have been a constant and enjoyable feature of the Association's activities. The first two-day field-meeting was conducted in 1863, and since 1871 outings of two days or more have been customary—apart from war years—at Easter and Whitsun. Moreover, during the summer months, long excursions. lasting up to a fortnight, have been arranged in various parts of the British Isles and on more than twenty occasions to Continental countries, including Austria, Belgium, Czechoslovakia, France, Italy, Norway and Switzerland.

One of the original aims of the Association was the printing of *Proceedings*, separate memoirs and notice papers. Until 1911 the *Proceedings* appeared every two years, but since then they have been issued as annual volumes in four parts, with maps and illustrations. Among the host of published papers, covering most facets of geology, a goodly proportion has dealt with the geomorphology and stratigraphy of southern England. Many of them rank as classical contributions to the literature of geology. The publication in 1910 of the jubilee volume, "Geology in the Field", describing areas in England and Wales visited by the Association, marked a milestone in its history. Apart from two months each summer, it has long been the practice to issue monthly circulars announcing forthcoming lectures and field-meetings.

The Association's century of progress has been largely due to the selfless devotion of its officers, and of the directors and secretaries of field-meetings at home and abroad, all of whom have willingly served without monetary recompense. Since 1900, the pleasant custom—never a rule—of electing presidents alternately from among amateur and professional members has been maintained with but one exception. The arduous office of treasurer and the key-post of general secretary have usually been in the competent hands of amateur members, while most of the editors have been professional geologists, and the less conspicuous but important roles of librarian and secretary to the Publications Committee have been filled by a line of enthusiasts, many of whom have served for long periods.

In the future, as in the past, amateurs will continue to be the mainstay of the Association; among their ranks there will always be some of international calibre, many will be active in the important task of assembling local details and recording ephemeral sections, and all will be attracted to the Association by a spirit of inquiry, by a stimulating out-door scientific pursuit with kindred souls, and by a love of Nature. Happy indeed is the Geologists' Association that it can look back with justifiable pride upon a hundred years of almost continuous expansion and progress, and forward in confident anticipation of still greater accomplishment.

Besides the launching of a series of guides, the centenary year is being commemorated by the publication of a volume entitled "The Geologists' Association 1858–1958", the delivery of several special lectures, the holding of a reunion on November 10 in the apartments of the Royal Society and the Geological Society, and a centenary year dinner on November 11 in the Connaught Rooms, London.

OBITUARIES

Prof. J. F. Joliot, For.Mem.R.S.

Le monde scientifique a été frappé par l'annonce de la mort de Jean Frédéric Joliot le 14 août à Paris.

Né le 19 mars 1900 à Paris, Frédéric Joliot a fait ses études d'ingénieur à l'École de Physique et de Chimie industrielles de Paris. Dans cette école il a pu profiter de l'enseignement de Paul Langevin, sur les conseils duquel il est entré en 1924 au Laboratoire Curie comme préparateur privé de Madame Pierre Curie.

Dans les premières années de son activité scientifique, Frédéric Joliot s'intéressait à la confection de minces écrans métalliques dans le but d'étudier leur conductibilité électrique. Depuis son mariage en 1926 avec Irène Curie, F. Joliot a commencé à s'intéresser aux problèmes de radioactivité et en 1930 il a soutenu sa thèse de doctorat ès sciences sur l'étude électro-chimique des radioéléments.

Esprit clair et méthodique il avait le don d'imaginer rapidement des expériences simples qu'il exécutait avec grande ingéniosité et habileté.

C'est entre 1932–34 qu'ensemble avec Irène Curie il a publié une suite de travaux remarquables qui dépassaient le cadre de la radioactivité proprement dite. En irradiant des cibles de glucinium par les particules α et en étudiant les radiations très pénétrantes signalées par Bothe et Becker en 1930, I. Curie et F. Joliot ont observé un nouveau phénomène très surprenant : un écran de paraffine placé dans le trajet de la radiation pénétrante devenait lui-même le siège d'une émission de protons de grand parcours, qu'ils expliquaient comme un effet photoélectrique de photons d'environ 50 MeV. sur les protons. L'observation de la projection des protons était importante pour la découverte du neutron, signalé peu de temps après par J. Chadwick sur la base d'expériences plus détaillées sur d'autres noyaux légers projetés dans différents écrans par le glucinium irradié par les particules α. Frédéric et Irène Joliot-Curie ont pu montrer à la suite le neutron était plus lourd que le proton.

Presque simultanément avec ces travaux I. Curie et F. Joliot ont fait des travaux importants sur l'annihilation du positon dans la rencontre avec un négaton et sur l'effet inverse, la création d'une paire négaton-positon dans la rencontre d'un photon γ pénétrant avec un noyau atomique lourd.

La découverte la plus remarquable de Frédéric et Irène Joliot fut celle de la radioactivité artificielle, couronnée par le prix Nobel de chimie en 1935. En irradiant des métaux légers, comme par exemple l'aluminium, par les rayons α, les époux Joliot ont observé que l'émission simultanée de neutrons et de positons cessait pour les neutrons, mais continuait à se produire pour les positons quand on enlevait la source α. L'intensité de l'émission des positons décroissait avec le temps comme le ferait une source radioactive naturelle. E. Fermi et ses collaborateurs ont pu bientôt étendre la radioactivité artificielle aux éléments émetteurs de négatons en bombardant des noyaux légers ou moyens avec des neutrons lents.

F. Joliot a fait des contributions expérimentales élégantes à l'étude de la fission de l'urane après capture d'un neutron. Avec Halban et Kowarski il a annoncé que la fission de l'urane est accompagnée de l'émission d'environ trois neutrons, ce qui a laissé entrevoir la possibilité d'une réaction en chaîne et la libération massive de l'énergie nucléaire. En 1940, Frédéric Joliot fait venir en Angleterre son important stock d'eau lourde provenant de Norvège.

Joliot est élu membre de l'Académie des Sciences de Paris en 1943. Pendant plus d'un an il est directeur du Centre National de la Recherche Scientifique, et il est nommé Haut-Commissaire au Commissariat à l'Énergie Atomique en 1945, dont il doit abandonner la direction en 1950 pour des raisons politiques. En 1956 il succède à Irène Joliot-Curie comme professeur à la Sorbonne et il devient directeur du Laboratoire Curie et des Laboratoires de Physique Nucléaire nouvellement installés à Orsay, près de Paris.

Pendant l'occupation Frédéric Joliot a milité dans la résistance ; pendant plusieurs années il a été président du Conseil Mondial pour la Paix.

Frédéric Joliot avait des manières simples et il était d'un abord facile. Quoique très tourmenté intérieurement, il avait une nature gaie et il se liait facilement d'amitié. Un deuil cruel frappe sa fille Hélène Langevin son fils Pierre et ses proches.

S. Rosenblum

Sir Douglas Mawson, O.B.E., F.R.S.

When towards the end of 1907 Ernest Shackleton passed through Australia on his way to the Southern Continent, the Australian Government gave him £5,000 towards the expenses of his venture, and in return he undertook to take Australian scientists with him. In doing so, they unwittingly turned the Pole-seeking quest of a gentleman adventurer into an expedition of major scientific importance. This same gift was also responsible for the introduction to polar exploration of the man who was destined to inspire and lead the first major Antarctic expedition in which adventure was subordinated to scientific inquiry. When *Nimrod* left Lyttelton, Douglas Mawson was a geologist already mature in experience and a lecturer in the University of Adelaide. In the next fourteen months he was destined to accompany his mentor, Edgeworth David, to the summit of Mt. Erebus through autumn frost and blizzard and to the South Magnetic Pole deep within the Antarctic plateau and back to the coast, a journey which involved well over a thousand miles of man-hauling of the severest kind.

Scott would have welcomed him on his final venture, but Mawson had finished with pole-seeking and had other fish to fry. In 1911 he left Australia with a well-found party sufficiently strong to man two bases the common objective of which was the scientific exploration and annexation of as much of the Antarctic coast south of Australia as could be covered in two years. With him he had the first air sledge and the first wireless installation ever to be established in Antarctica. In March 1913, this station, in spite of gales averaging 50 miles an hour for month on month—for he had chosen as his main headquarters the stormiest region of the whole landmass, where katabatic gales sweep downwards to the coast throughout the year—transmitted direct to Australia that first dramatic message recording Mawson's return from an ordeal I believe no other

man I have known could have survived. After losing one companion and practically all the party's food down a crevasse and seeing a second companion die of starvation and over-exertion by his side, he cut his tent down to half a tent, his sledge down to half a sledge and trudged into his headquarters after three further weeks man-hauling alone on just enough food to keep body and soul together.

It is a measure of Mawson's courage and determination that his second enforced year's stay saw the carrying through of scientific work as fine in quality as that of the preceding year when all was going well. A stream of memoirs that kept the Australian Government Press busy off and on for forty years is one fitting tribute to an enterprise brilliantly planned and executed in the face of exceptional difficulties.

In the years following 1913 Mawson did outstanding work as field geologist and teacher; but Antarctic science remained a major interest throughout a long life that came to an end on October 15. He went to Antarctica again in 1929 and 1930, when he discovered MacRobertson Land, Queen Elizabeth Land and the Mackenzie Sea, using a seaplane to increase his range of action. Since the Second World War he has been a driving force behind the Australian Antarctic organization, A.N.A.R.E. When Prince Philip visited Australia in *Britannia* in 1956, it was Mawson who took the chair at the Antarctic symposium that was one important feature of the Melbourne programme, and the paper he delivered showed that his interest was as strong as ever and his intellect as keen. In courage, determination, singleness of purpose, breadth of scientific interest and quality of mind, he was Australian man at his best and he will be sorely missed. No one will regret his passing on more than the few surviving companions of his early adventurous days.

RAYMOND PRIESTLEY

Prof. F. A. Paneth, F.R.S.

WORKERS throughout the world in many branches of science have learned with deep regret of the death in Vienna on September 17 of Dr. Friedrich Adolph Paneth, a director in the Max-Planck-Institut für Chemie in Mainz and emeritus professor of chemistry in the University of Durham.

Paneth was born in 1887 in Vienna, where his father was lecturer in physiology in the University. After studying science at the University of Vienna, he moved to Munich and, later, to Glasgow, where he worked for a year in the laboratory of Frederick Soddy. In 1912 he was appointed assistant at the Vienna Radium Institute, and six years later to a chair at the Prague Institute of Technology; during the ensuing fifteen years he held similar posts in the Universities of Hamburg, Berlin and Königsberg. The events of 1933 in Germany caused him to leave that country and to seek refuge in London, where accommodation was found for him at the Imperial College of Science and Technology; the welcome he received there was later put on a more formal basis by his appointment to a readership in atomic chemistry. In 1939, Paneth was appointed to the chair of chemistry at Durham, from which he retired in 1953 on reaching the age-limit. Even then he was not content to give up active scientific work, but returned to Germany to take up the post at Mainz which he held until his death.

Paneth's early education had been broadly based—to the end of his life he retained a keen interest in the humanities—and he was never in danger of too narrow a specialization in his work. His first major contribution, dating from his time at the Vienna Radium Institute, was made when he and Hevesy laid the foundations of the modern use of radioactive isotopes as tracers. At that time, of course, only lead and bismuth among the common elements were available in a usable radioactive form; but Hevesy and Paneth not only demonstrated that such materials could be used to follow the details of chemical reactions, but also went on to investigate in some detail the behaviour of trace quantities of such substances in precipitation, adsorption, electrochemical and colloid experiments.

After leaving Vienna, Paneth continued with this fundamental radiochemical work, but he was also led, by one of those almost accidental steps which not infrequently precede big developments in science, to the experiments which conclusively demonstrated the transitory existence of the simple aliphatic free radicals—perhaps his most important contribution to pure chemistry. He had been using the extreme sensitivity of the radioactive indicator technique to demonstrate the existence of the hydrides of lead and bismuth, and went on, with Hofeditz, to examine the pyrolysis of tetramethyl lead carried, in a stream of hydrogen, rapidly through a heated quartz tube. They demonstrated, in a classic series of experiments, that the immediate products of the pyrolysis are metallic lead and free methyl radicals, and established a procedure that has since found wide use in studies of free radicals. During this period he was also refining the technique of measurement of the very small quantities of helium formed—as α-particles—in radioactive decay processes. This work was continued after Paneth's arrival in Britain, and increasingly applied to the problem of 'age determination', especially of meteoritic materials. He began also to turn his attention to some chemical aspects of meteorology and, in collaboration especially with E. Glueckauf, much careful work was done on the concentrations of the minor constituents of the atmosphere.

On account of the Second World War, Paneth achieved little in Durham until 1945, when he returned from Montreal, where he had spent two years with the joint British–Canadian Atomic Energy Laboratory to which he had been seconded. He was determined to set up in Durham a research laboratory devoted to radiochemical studies and, with characteristic indifference to the administrative difficulties of the immediate post-war period, he achieved his aim: the Londonderry Laboratory for Radiochemistry was formally opened in June 1947. Here the work on the rare gases, which was now Paneth's main interest, was pressed forward, with especially intensive work on the problem of the ages of meteorites. The atmospheric work was also continued, in collaboration with the U.S. Air Force, which carried out experimental rocket firings to obtain samples of air from very great heights for analysis.

Paneth was keenly interested in the history and philosophy of science (and, indeed, in philosophy in wider contexts) and was often consulted about the naming of newly discovered elements, and other questions of chemical nomenclature. As president (from 1949 until 1955) of the Joint Commission on Radioactivity of the International Council of Scientific Unions, he provided a useful link between the physical and chemical approaches to problems of standardization in radioactivity. In 1926 he had been George Fisher Baker Lecturer at Cornell University, and his lectures formed the basis of his book, "Radioelements as Indicators"; with Hevesy he was the author also of "A Manual of Radioactivity", long regarded as a standard work on classical radioactivity. Paneth was elected to the Royal Society in 1947, and was honoured by many other learned societies, both in Britain and abroad.

It is clear that on his record as a scientist, Paneth is assured of a place in history, but something remains to be said of him as a person. He would not have counted himself a great experimentalist; rather his contribution was to create the conditions in which good work could be done—by selecting a happy team of collaborators, ensuring that they were not impeded by lack of equipment, and providing the necessary intellectual stimuli. He knew how to delegate responsibilities, and his colleagues knew that they could rely on his loyal support in anything they did on behalf of the Laboratory. Paneth was a natural linguist, and his command of English was extraordinarily good for one thrust into its use at so late a stage in his career. He was greatly in demand as a lecturer, and had a particular flair for exposition at the non-specialist level. These lectures were prepared with great care, and they were masterpieces of presentation, with just the correct blend of history, philosophy, wit, and hard scientific fact.

Paneth was a man of great personal charm—he can, for example, have had few peers in the matter of persuading museum curators to part with samples of meteorites—and he was blessed with a keen sense of humour. The numerous visitors to his Laboratory who enjoyed the hospitality provided at his home will long cherish memories of evenings of stimulating and amusing conversation. Their deepest sympathy will be extended to his widow, and to the son and daughter who survive him.

G. R. MARTIN

NEWS and VIEWS

Nobel Prize for Chemistry: Dr. F. Sanger, F.R.S.

DR. FREDERICK SANGER, who has been awarded the Nobel Prize for Chemistry for 1958, is a member of the staff of the Medical Research Council, and has spent the whole of his research life in the Department of Biochemistry, University of Cambridge, the University of which he was an undergraduate. The award has been made for his researches on the structure of the protein hormone insulin, the elucidation of which he completed in 1955, at the age of thirty-seven, after ten years of intensive research. The methods which he developed for this purpose are a model of effectiveness. When he began his investigations on insulin, Dr. Sanger first devised the use of dinitrofluorobenzene for the identification and estimation of the free amino-groups of proteins or peptides, and this method has since been widely adopted. By 1949 Sanger had shown that oxidation of insulin with performic acid, to break disulphite bonds, led to two separate fractions. Partial hydrolysis of the two separated portions with acid, and later with enzymes, yielded a series of peptides which he isolated by chromatography. The application of the dinitrofluorobenzene method to the peptides enabled Sanger and his colleagues to determine the sequence of amino-acids in the peptides, and so to deduce the sequences in the two large portions which had been formed by the oxidative fission of the insulin molecule. The results were such that a unique sequence of amino-acids could be ascribed to each of the two portions of the molecule. The determination of the position of the disulphide linkages involved the subjection of insulin to partial hydrolysis by enzymes under conditions in which the disulphide bonds remained stable. The cystine-containing peptides in the hydrolysate were separated and their structures determined by the methods he had previously developed. The structures of the cystine peptides which thus were elucidated showed that only one solution was possible to the problem of the distribution of the sulphide bonds in insulin. Two of these formed junctions between the two main peptide chains of the molecule, while a third disulphide link spanned four amino-acid residues in a manner similar to that previously deduced by du Vigneaud and his colleagues for the hormones oxytocin and vasopressin. Afterwards, Sanger and his colleagues showed that certain of the amino-acids within this intra-chain disulphide link differ in insulins from different species. Dr. Sanger's methods and example have stimulated much research in the investigation of protein structure, the limits of which have yet to be visualized, and they make clear the possibility that insulin may be completely synthesized in the laboratory, although this is unlikely to occur for some time to come.

Nobel Prize for Physics: Dr. P. A. Čerenkov, Dr. I. M. Frank and Dr. I. Tamm

THE award of the Nobel Prize for Physics for 1958 to the Russian physicists, P. A. Čerenkov, I. M. Frank and I. Tamm, for their work in the discovery and interpretation of the nature of Čerenkov radiation, is a fitting recognition of a scientific advance which has acquired great importance for experimental high-energy nuclear physics and cosmic rays. Čerenkov's contribution was to make, in 1934, a detailed study of the light emitted by liquids when they were exposed to radiations from radioactive substances. That certain substances were fluorescent under the influence of such radiations had been known since the days of Becquerel, but whereas fluorescent light depended markedly on the chemical nature of the substance, a weak residual light was found to be emitted even when all traces of fluorescent substances had been removed. This light was named the Čerenkov light; it was given a theoretical interpretation by Frank and Tamm in 1937. Frank and Tamm showed, on the basis of classical electromagnetic theory, that a charged particle travelling through a medium with a velocity greater than the velocity of light in that medium gives rise to an electromagnetic shock wave. This shock wave, which is analogous to the bow wave produced in water by a fast-moving ship, constitutes the Čerenkov radiation. Čerenkov light can only be observed in a medium which has a sufficiently high refractive index to bring the velocity of light in the medium below that of the charged particle; and it is emitted (like a bow-wave on water) at a definite angle to the direction of motion of the charged particle, the angle being a function of particle velocity. Modern Čerenkov counters make use of these properties to distinguish between particles of different velocities which emerge from the targets of the giant particle-accelerating machines.

Atomic Energy Patents: Mr. J. A. Gay

MR. J. A. GAY has been appointed patents exploitation officer to the United Kingdom Atomic Energy Authority in succession to Mr. T. Benson Gyles. Mr. Gay, who is thirty-six and graduated at University College, London, was formerly in the Commercial Department of the Authority's Industrial Group. In 1949 he was appointed development engineer to Standard Telephones and Cables, and in 1951 joined Messrs. O. W. Roskill, industrial consultants, as senior engineer. During 1953–56 he was with Isotope Developments, Ltd., and in 1956 joined the Authority's staff at Risley. Inventions developed in the course of atomic energy work and which are available for commercial exploitation continue to be filed at the rate of about eight a month. Many of them may be applied in a wide variety of industries, both inside and outside the atomic energy field, and the total number of inventions available for use by firms is now more than 400.

U.S. International Co-operation Administration: Visit to Africa

THE U.S. International Co-operation Administration is the organization through which the U.S. Government channels its funds for aid, of all kinds, to the different countries of the world. The Administration is the successor to the various agencies which have fulfilled this role since the days of the Marshall Plan and is closely associated with the U.S. State Department. For some months, the Administration has been exploring the possibilities of greater utilization of the scientific resources of the United States, and other countries, in attacking the problems of under-developed countries and territories, particularly in tropical Africa. The director of the Administration, Mr. James H. Smith, has started this week on a tour throughout tropical Africa, to examine on the ground the scientific work which is in progress. He is accompanied by Mr. Joseph C. Satterthwaite, recently appointed Assistant Secretary of State for African Affairs in the State Department, Dr. J. G. Harrar of the Rockefeller Foundation, Dr. Richard Bradfield, agronomist of Cornell University, and Dr. John M. Weir, who is working on tropical medicine for the Rockefeller Foundation. The Administration recently informed the Lord President's Office that Mr. Smith hoped to include two scientists from the United Kingdom in the party. In response to this invitation, arrangements have been made for Prof. G. B. Maegraith, professor of tropical medicine, University of Liverpool, and Mr. Dunstan Skilbeck, principal of Wye Agricultural College, to fly out this week to Africa and join Mr. Smith's party. The itinerary starts in Liberia and proceeds through Ghana, Nigeria, Kenya, Ethiopia, Sudan and Tunis.

Commonwealth Fellowships

THE new scheme for Commonwealth Fellowships, announced at the Montreal Conference in September, was warmly welcomed in both Houses of Parliament in the debate on the Queen's Speech on October 28 and 30. The scheme provides for 1,000 scholarships a year and Great Britain has announced her willingness to take half, while at the same meeting Australia announced that she was increasing her scholarships under the Colombo Plan by 150. There are now 38,000 Commonwealth and overseas students in Great Britain compared with 10,000 in 1951, and 10–12 per cent of all places in British technical colleges are occupied by overseas students, two-thirds of whom come from the Commonwealth: at the Imperial College of Science and Technology the percentage of overseas students is 38 and at the British Postgraduate Medical Centre, 60. Earl Jellicoe, in welcoming the scheme, referred to the crucial importance attached to education by all Commonwealth countries at Montreal and to the need for Britain to remain a great reservoir of humane wisdom and technical knowledge on which the Commonwealth and the free world could draw. Mr. P. Maitland particularly welcomed the assurance that these 1,000 scholarships for the interchange of Commonwealth advanced students would cover the humanities as well as science and technology; and Mr. J. Dugdale referred to the asset which such scholarships represented in Commonwealth relations and also to the value of an inter-Commonwealth service of technical experts.

National Science Foundation: Research for Teachers and Travelling Lectures

The U.S. National Science Foundation has invited universities, colleges, and other non-profit institutions with appropriate research facilities to submit proposals for support of Research Participation Programmes for Teacher Training. It is planned to support a limited number of experimental programmes which will provide research experience during the summer months for teachers of science and mathematics in high schools and small colleges, under the guidance of experienced scientific investigators. Courses combining laboratory experience with seminars on scientific subjects and research techniques will be provided with the objective of improving science teaching. Support will be provided by the Foundation for stipends and travel for approximately 700 teachers and for expendable supplies, secretarial and administrative expenses, and other institutional costs directly attributable to the teacher training aspects of the programmes.

The National Science Foundation is also to expand its programme of travelling science demonstration lectures, previously administered solely by the Oak Ridge Institute of Nuclear Studies, Tennessee, to include a few regional centres throughout the United States. Individuals will be selected by the regional centres to receive three summer months of intensive training designed to prepare teachers to give lecture-demonstrations in physics, chemistry, biology or mathematics in a number of high schools during the school year 1959–60. Emphasis is on fundamental scientific principles which can be demonstrated by simple equipment which teachers can construct. Each travelling lecturer will spend three to five days at 30–40 representative secondary schools throughout the area served by the regional centre, giving demonstrations using the special equipment which they carry with them, and assisting local science teachers.

Unesco Research Ship

A PROPOSAL that Unesco should sponsor an international research ship was strongly supported by a group of international marine scientists who have just concluded a series of meetings in Paris. The meeting was called to discuss Unesco's role in promoting international co-operation for oceanic exploration and was attended by consultants from scientific organizations in Australia, Denmark, Finland, France, the German Federal Republic, Italy, the Netherlands, Norway, Poland, Sweden, the United Kingdom, the United States and the U.S.S.R. The ship, it was pointed out, would supplement research already being carried out on a national basis by some of the larger countries and could also tackle oceanographic problems that cannot be undertaken by the existing ships. To meet this task, it was suggested that the ship should be of about 1,200–1,300 tons and some 220 ft. long. Laboratory space would be provided for six permanent scientists and additional accommodation for fifteen visiting experts and students in training. A supplementary proposal recommended that Unesco should operate a number of chartered research ships on an international basis. Emphasizing the importance of increasing the food resources of the world by development of the oceans' potentialities, the consultants also urged that Unesco and the United Nations Food and Agriculture Organization should direct the attention of all governments to the importance of marine research. Further specific aid was requested from Unesco in the form of research contracts for individual workers and laboratories, fellowships for training purposes, travel allowances for scientists participating in international co-operative projects, the assignment of experts to countries requiring technical assistance in this field and the provision of equipment and facilities for co-operative projects between countries. These proposals are being submitted to the Director-General of Unesco for further examination.

McGill University, Faculty of Engineering

The Faculty of Engineering of McGill University, in common with those of all other Canadian universities, is expecting a continuing growth in the number of applicants over the next decade, and is also anxious to encourage postgraduate studies to a greater extent than hitherto. The present buildings have been basically unchanged for some fifty years, although during that time, and particularly since 1945, relatively small additions have been made to accommodate the increased number of students admitted. In the session 1957–58 there was a total of some 1,800 undergraduate students in the Faculty, which represented the absolute maximum that the present buildings could take. In May 1958 ground was broken for a new engineering building to supplement the present facilities. This building, with an area of some 140,000 sq. ft., has been designed to provide lecture rooms and drafting rooms, particularly for the students in the earlier non-specialized years of the course ; to give, for the first time, proper quarters to the School of Architecture, and to provide completely new quarters for the Department of Electrical Engineering which was formerly housed in the old building. The release of this space from the old building will permit expansion of the Departments of Mechanical and Civil Engineering, where heavy installed equipment made it preferable to expand *in situ* rather than move into completely new quarters.

Mr. J. W. McConnell, the senior governor of the University, has made a magnificent gift which will cover the complete cost of this new building, which is expected to be opened in October 1959. The extra space then made available will make it possible for the faculty to embark upon a programme aimed primarily at the development of honours and graduate students in engineering, as well as permitting improvement in the quality of, and a small increase in the numbers admitted to, the ordinary engineering courses. The programme leading to the development of graduate work is already under way, and it is hoped soon to make appointments to three new chairs which have been created in control engineering, mining engineering and applied mechanics, and propulsion. It is also hoped that in the next few years a number of additional chairs will be created so that full use can be made of the new facilities.

Higher Education in the United Kingdom

The revised edition of the handbook for students from overseas issued by the British Council and the Association of Universities of the British Commonwealth under the title "Higher Education in the United Kingdom" (pp. 208. London: Longmans, Green and Co., Ltd., 1958. 5*s*.) contains much useful information. Thus it includes, besides a dictionary of subjects and facilities for study and the lists of addresses of universities, technical colleges and other institutions, which occupy the greater part of the handbook, tables of fees and notes on the cost of study and residence, and on life in a British university or technical college. There is a foreword by Dr. R. S. Aitken, and a short article on universities in the United Kingdom by Sir James Mountford and another on technical education by Dr. P. F. R. Venables. The handbook brings together much information of great value not merely to overseas readers but also to those in Britain who are concerned with advising and placing students.

British Commonwealth Collections of Micro-organisms

The United Kingdom National Committee of the British Commonwealth Collections of Micro-organisms is about to prepare a new edition of the "Directory of Collections and List of Species maintained in the United Kingdom and Crown Colonies". Directors of laboratories whose names appear in the 1951 edition will be asked to revise the information given in that directory, and to supply lists of micro-organisms now available for distribution. Other laboratories may have established general or specialized culture collections since the 1951 Directory was prepared, and if they are willing to make their cultures available to other interested workers they are asked to send lists before December 31 to Dr. S. T. Cowan, Secretary of the U.K. National Committee, at the National Collection of Type Cultures, Central Public Health Laboratory, Colindale Avenue, London, N.W.9.

Library Classification

A scholarly address, "Library Classification and the Field of Knowledge", delivered by Mr. D. J. Foskett at the annual general meeting of the North Western Group of the Reference and Special Libraries Section by the Library Association in Manchester, on February 26, has been issued by the Association as Occasional Paper No. 1 (pp. 15. London: Library Association, 1958. 2*s*. 6*d*.). Systems of classification, Mr. Foskett shows, arise not empirically merely as a practical convenience but as reflexions of the state of scientific and philosophical thought in any age, bringing together these parts of the field of knowledge that are seen to be clearly related. One must always be prepared to amend or overthrow existing systems which fall short of the requirements. Such discord as exists between the general classification systems and the requirements of modern research should not be allowed to continue.

Siemens Edison Swan Journal

THE format of the first number of the *Siemens Edison Swan Journal* (1, Summer 1958. Pp. 1–64. London: Siemens Edison Swan, Ltd., 1958) is remarkably good, as also the standard of the six articles which make up the contents. Tear-off abstracts in English, French and German complete with universal decimal classification numbers are provided. The *Journal* has been launched, the managing director, Dr. J. L. Aldington, says in his foreword, in order to provide additional opportunities for the staff to announce their achievements, and in one sense will supplement the technical press and journals of the learned societies, which from time to time include original contributions from the Company's staff, and in another sense will replace the old *Siemens Engineering Bulletin* by a more permanent and comprehensive record of the Company's contribution to electrical technology. The articles include a description of the "Centenary Neophone", a completely new telephone handset which the Company has recently produced, the main features of which are printed wiring, improved performance at lower cost, and reduction in size and weight; a review of recent applications in the light electrical engineering and cable industry; a brief discussion of some photoconductivity effects in grown crystals, particularly cadmium sulphide; and a survey of the manufacture of grids for radio valves.

Biochemical Pharmacology

THE first number has recently been published of a new international journal, *Biochemical Pharmacology* (1, No. 1; July 1958. Pp. 104. Subscription, including postage: (*A*) £6 (U.S.A. 17 dollars); (*B*) for subscribers certifying that the journal is for their own personal use, £5 5*s*. (15 dollars per annum). Four issues per volume. London: Pergamon Press, 1958). The journal will be devoted to "research into the development of biologically active substances and their mode of action at the biochemical and sub-cellular level". It will be under the guidance of an editorial advisory board containing many distinguished names from Europe and America. Papers will be in English, French or German. Short communications for quick publication will be accepted as well as full-length papers. It is intended to give emphasis to cancer chemotherapy and related studies, and this policy is reflected in the series of papers published in the first issue.

The Lichenologist

A NEW society, the British Lichen Society, founded early in 1958 to encourage the study and conservation of lichens, and conscious of the need to make up for past neglect of this interesting group of plants on the part of contemporary botanists, has now issued the first number of its journal, *The Lichenologist* (*Curator*, Dr. T. D. V. Swinscow, Everley, London Road, Knebworth, Herts.; *Hon. Secretary*, A. E. Wade, National Museum of Wales, Cardiff. Annual subscription and journal, 20*s*.). The major aims of the journal are to instruct and to communicate new information on taxonomic, distributional and ecological aspects. The first issue contains useful articles on the British species of *Cladonia* and *Collema*, notes on arctic–alpine and other lichens new to England, procedures for collecting and preserving lichens, and so on. This effort deserves the support of all who are interested in this group.

Foxboro-Yoxall's Training School

THE training school started in 1951 by Foxboro-Yoxall Ltd. at Wandsworth has now been moved to Redhill, Surrey. These premises have a greatly increased capacity, but in order to maintain an individual approach, courses are at present limited to nine students. The courses are of three weeks duration and comprise a maintenance course (*A*), designed to give instrument mechanics with limited experience in industrial instrumentation, practical training in the use and maintenance of Foxboro equipment; an advanced instrument course (*B*), designed for technical instrument engineers and covering the theory of control instrumentation and its application to industrial processes. Special courses related to particular user industries are also given from time to time. These have recently included one on instrumentation in the paper industry and another on instrumentation for coal-washing plants.

Leprosy Research Fund

THE Leprosy Research Fund was established in 1953, when Dr. R. G. Cochrane (of the Leprosy Research Unit, 11*a* Weymouth Street, London, W.1) was appointed technical adviser to the American Leprosy Missions, which had given financial aid to his researches on the histopathology of leprosy. The aim of the Fund is not to finance large research schemes, but to stimulate pilot research projects and inquiries. The Fund does not in any way compete with other organizations. It seeks, in fact, to help other organizations by indicating, through its pilot researches, problems that are sufficiently important to merit further consideration. The Fund also undertakes preliminary clinical trials of new drugs likely to be useful for the treatment of leprosy. For investigations of this kind only advanced lepromatous cases are taken, and the Fund is in touch with institutions all over the world. The Fund has studied the histopathology of leprosy for several years and has been able to supply workers with typical histological pictures of the various types and groups of leprosy. The Fund proposes to establish a unit containing a registry of clinical, photographic and histological records of the various types and groups of the disease, together with sets of slides, so that a world picture of the disease may be obtained for reference. It is estimated that the cost of such a unit will be about £2,300 a year.

National Museum of Wales

THE National Museum of Wales has recently issued a new edition of its "Illustrated Guide" (pp. 39 + 2 plates. Cardiff: National Museum of Wales, 1958. 1*s*. 6*d*.). It is, indeed, more than a new edition, for the subject-matter has been entirely re-cast and new illustrations have been included. The format is interesting and attractive and the typography clear and easy to read. Following a few notes on the building, well illustrated by clear plans, each department is dealt with in rotation but on a common plan. The purpose and policy of each is stated and brief allusion is then made to the chief exhibits. The "Illustrated Guide" is completed by an impressive list of publications and the whole is a model of what museum guides should endeavour to be.

Gibberellic Acid-like Substances in Higher Plants

As earlier studies have shown, gibberellic acid has notable growth-promoting effects when applied to dwarf varieties of *Pisum*, *Phaseolus* and maize, whereas tall varieties may be little affected. In an investigation of the distribution of substances similar to gibberellic acid in higher plants, M. Radley has demonstrated the presence of such substances in extracts made from seeds and from all parts of seedlings of tall and dwarf peas and from mature seeds of wheat and french beans (*Annals of Botany*, N.S., 22, 297 ; 1958). These substances were present in amounts equivalent to 0·1–0·3 μgm. gibberellic acid in 100 plants. It is stated that larger quantities were obtained from immature runner bean seeds, the substance being distributed between testas, cotyledons and embryos. A new biological test for gibberellic acid-like materials is described.

University News : Leeds

The following gifts have been received among others by the University of Leeds : £1,500 to the Department of Inorganic and Structural Chemistry from the Royal Society for scientific investigations on high-resolution nuclear magnetic resonance spectroscopy ; £700 to the Department of Botany from the Royal Society to purchase special equipment ; £1,000 to the Department of Civil Engineering from the Cement and Concrete Association towards the postgraduate course in concrete technology ; £2,715 to the Houldsworth School of Applied Science over three years from the Department of Scientific and Industrial Research for research on the brittle fracture of metals ; and £500 from the Shell Group of Oil Companies for postgraduate research in chemical engineering ; £700 a year for three years to the Department of Biochemistry from the Wellcome Trust for the salary and expenses of a research assistant.

The following have been appointed lecturers : Dr. P. B. Ayscough in the Department of Physical Chemistry ; Dr. R. G. Burwell in anatomy ; Dr. A. J. Kenny in biochemistry. The title of reader in textile physics be conferred upon Mr. H. J. Woods, senior lecturer in textile physics.

London

Mr. F. H. Ludlam, lecturer in the Department of Meteorology at Imperial College of Science and Technology, has been appointed to the readership in meteorology at the same College. The title of reader in aerodynamics in the University of London has been conferred on Mr. L. E. Fraenkel in respect of his post at the Imperial College of Science and Technology. The title of reader in biology in the University of London has been conferred on Dr. H. Kalmus in respect of his post at University College.

Sheffield

The title of emeritus professor of zoology has been conferred on Prof. L. E. S. Eastham, who retired recently (see *Nature*, 181, 1307 ; 1958). The following appointments have also been made : Mr. P. R. Becker, to be lecturer in the Electronic Computation Laboratory ; Dr. P. E. Brown, to be lecturer in geology.

Announcements

Mr. J. Tankard (British Rayon Research Association, Wythenshawe, Manchester) and Dr. F. O. Howitt (Wool Industries Research Association, Leeds) have been awarded Service Medals of the Textile Institute. The Service Medal was first awarded in 1940 and is given for valuable services rendered to the Textile Institute.

Starting with the January 1959 issue, Consultants Bureau, Inc., is undertaking the translation of all non-English articles appearing in each issue of the *Czechoslovak Journal of Physics* (annual subscription : 6 issues, 50.00 dollars). Further information can be obtained from Consultants Bureau, Inc., 227 West 17th Street, New York 11.

A symposium on "The Chemistry of Co-ordination Compounds", organized by the National Academy of Sciences, India, will be held in Allahabad on February 7 and 8. Further information can be obtained from Dr. Arun K. Dey, Department of Chemistry, University of Allahabad, India.

It is proposed to hold a symposium on "Cultural and Metabolic Aspects of Moulds", organized jointly by the Society for Applied Bacteriology and the Istituto di Sanita in Rome in the spring of 1960. The symposium will be open to *bona fide* workers in this field whether they are members of the Society or not. Those interested should write to Mr. G. Sykes, Boots Pure Drug Co., Ltd., Microbiology Division, Standard Department, West Bridgford, Nottingham, as soon as possible.

An international symposium on antibiotics will be held in Prague during May 17–23. The proceedings will be divided into three sections, dealing with problems of the biosynthesis of antibiotics ; the scientific pathophysiological basis of antibiotic therapy ; and the problems of fermentation technology and non-medical use of antibiotics. Further information can be obtained from the secretary of the symposium, Dr. M. Heřmanský, Antibiotics Research Institute, Roztoky, near Prague, Czechoslovakia.

A joint endocrine meeting will be held at the Royal Society of Medicine on April 24 and 25, 1959. It will be sponsored by the Section of Endocrinology of the Royal Society of Medicine and the Society for Endocrinology with the participation of the Society for the Study of Fertility, the Medical Section of the British Diabetic Association, the London Thyroid Club and the Endocrine Club, Glasgow. Short papers will be read and a dinner will be held on April 24. Further details can be obtained from the Honorary Secretary, Section of Endocrinology, Royal Society of Medicine, 1 Wimpole Street, London, W.1.

Erratum. In the communication entitled " 'Solubilization' of a Cytochrome *b* Component from *Micrococcus lysodeikticus*", by F. L. Jackson and Valerie D. Lawton in *Nature*, 182, 799 (1958), para. 3, line 7, for "529–530 mμ" read "429–430 mμ". This was overlooked in proof by the authors.

THE UNIVERSITY CHEMICAL LABORATORY, CAMBRIDGE

THE formal opening of the new University Chemical Laboratory in Cambridge by Princess Margaret on November 6 marks a deeply significant change in the topographic distribution of the University science laboratories. Hitherto, these had been compactly—in fact, all too compactly—built on each side of the Pembroke Street - Downing Street axis, physics, chemistry and zoology being on the north side of this axis, and geology, mineralogy and the other biological sciences on the south side of Downing Street. The Chemical Laboratory was originally built in 1887 at the corner of Pembroke Street and Free School Lane, but required several additions as the numbers of students increased : the two major additions occurred in the early 1920's, when the new organic wing was built with a considerable grant from the British oil companies, and when physical chemistry occupied the building in Free School Lane vacated by the Engineering Department. At the end of the Second World War, the Chemical Laboratory, by virtue of this piecemeal and improvised growth, had lost its original design and had become both inconvenient and uneconomic (in man-power and material) to run, was congested with students, and lacked space to house the modern equipment which it so badly required. The decision to migrate from the traditional science centre to the new site in Lensfield Road was based primarily on the virtual impossibility of rebuilding adequately on the old site, and also on the value of this site for the subsequent expansion of its cramped neighbours : the means for this migration were provided by a sympathetic Government Grants Committee, supported on the personal side very largely by the vigorous and steadfast appreciation of the position by Sir Alexander Todd.

The new laboratories consist essentially of two long rectangular blocks running parallel to Lensfield Road in an east–west direction, the block nearer to Lensfield Road accommodating the Department of Physical Chemistry and the other more distant and higher block accommodating the Department of Organic and Inorganic Chemistry. The two blocks are joined at the western end by a narrower block, which houses an additional part of physical chemistry, and also theoretical chemistry, spectroscopy, the library, administrative offices and canteens.

Between the two main blocks, on the ground floor, are two lecture-rooms each holding about 200 students, and a third lecture-room, to hold 450 people, is being added for both departmental and general University purposes.

At the east end of the organic–inorganic block an L-shaped extension is being constructed to provide extra research facilities and to accommodate the first- and second-year students in these branches of chemistry. When this extension becomes available, the migration of all chemical teaching and research from Pembroke Street to Lensfield Road will be complete, and the University of Cambridge will possess one of the most commodious and best-equipped laboratories for chemical teaching and research in the United Kingdom.

The main organic–inorganic block was constructed first and has now been in occupation for some time. The central portion consists of a basement which houses the store-room, workshops and (at the east end) the central heating station ; the ground floor is devoted to third-year organic teaching, the first and second floors to organic research, the third floor to inorganic and radiochemical research, and the fourth floor contains the plant room for the mechanical services, particularly those for the ventilation of the building and for the fans.

The central portion of the main physical chemistry block has a basement which contains the store-room, workshop and research accommodation, two floors devoted to teaching, a third floor to research, and a fourth floor which also houses a plant room.

The gross floor area of the complete building will be approximately 238,000 sq. ft.

The construction of the two major blocks embodies a number of novel features. In particular, the steel frame is built up of horizontal lattice girders, each about 45 ft. long × 3 ft. deep, welded together side by side to form a continuous frame on which each floor is constructed from pre-cast concrete slabs and a 3-in. concrete screed. These girders span the entire width of the blocks without internal columns, and thus allow the large teaching laboratories on the lower floors to be completely unobstructed, while on the research floors above considerable flexibility for subdivision is possible. The wall piers are of composite steel and concrete construction, the external walling being otherwise of 13½-in. solid brickwork faced with brown Buckinghamshire bricks.

The space within the lattice frame of each floor contains the horizontal runs of electrical and mechanical services. Hot-water heating pipes, which are attached to the underside of the frames, form, with removable aluminium panels, the heated Frenger ceilings.

The research floors have a central corridor, 6 ft. 9 in. wide, with rooms and laboratories on each side assembled on a modular basis, each module being fully serviced ; these research laboratories are separated by fireproof reinforced plaster panel partitions, which being non-structural are removable, so that the number of moduli forming any laboratory can be changed without undue trouble.

All laboratories are supplied with cold water at high and low pressure, with hot water (maximum temperature, 65° C.), distilled water, gas and compressed air (15 lb./sq. in.) ; certain laboratories are also provided with high-pressure air (100 lb./sq. in.), steam, reduced pressure (10 mm. mercury), and with oxygen. A water-softening unit, of capacity 400 gallons per hour, in the boiler house provides the water required for the steam generator, and for the automatic still which delivers distilled water into two 500-gallon polyethylene-lined storage tanks, whence it is fed through polyethylene pipes to all the individual laboratories. Polyethylene piping is also used to convey all cold effluent from the laboratory sinks, drip wastes, fume cupboards, etc., to the horizontal 4-in. bore cast-iron pipes which run through the

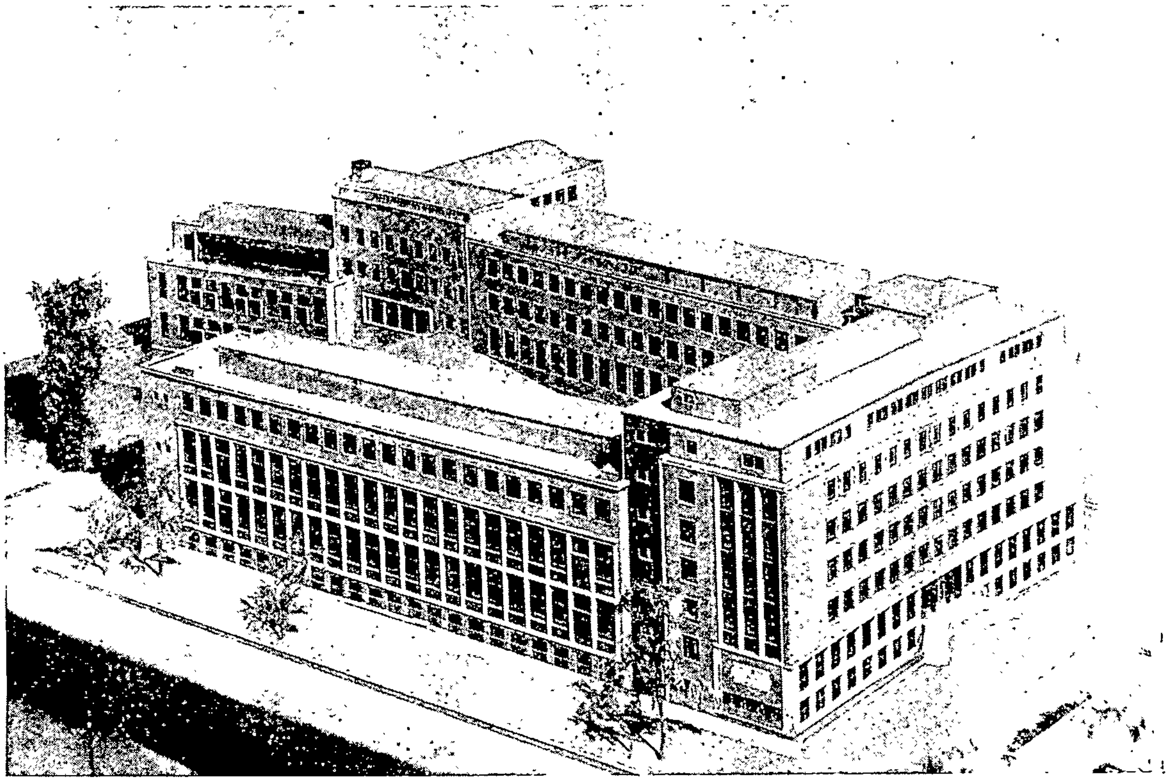


Fig. 1. University Chemical Laboratory, Cambridge. Photograph of the complete model of the Laboratory, viewed from the north-west. The main entrance is shown on the right. The long block in the foreground is occupied by the Department of Physical Chemistry, and that in the background by the Department of Organic and Inorganic Chemistry: the lecture rooms lie between these blocks. The two smaller blocks at the far left-hand corner are still under construction

lattice girders, and which are coated internally with acid-resisting plastic paint. Hot effluent from steam outlets is, however, carried through intermediate lead or stoneware piping.

To allow the desired flexibility in the size of the research laboratories, the teak bench tops are supported on cantilever brackets which fit into service racks designed to carry the tops at sitting or standing height, or to enable them to be completely removed. Independent cupboards of standard size but of various internal designs fit snugly beneath the bench tops: a research worker can thus choose a selection of cupboards suitable for his own work.

The design and construction of this Laboratory have presented many difficult and often novel problems. The University is particularly indebted to Mr. J. Murray Easton and Mr. S. E. T. Cusdin, of Messrs. Easton and Robertson, the architects, and to Mr. A. R. Gilson, the former superintendent of the Laboratory, who has closely and very effectively co-operated with them for the success of this project, which, in the hands of the contractors, Messrs. Kerridge and Co. (Cambridge), Ltd., and Messrs. Rattee and Kett, Ltd., has provided a chemical laboratory in which the University may well take great pride.

F. G. MANN

COSMIC RAYS

CONFERENCE AT DURHAM

A PHYSICAL Society Conference on "Cosmic Rays" was held in the Durham Colleges in the University of Durham on September 24 and 25. About one hundred delegates from most of the European centres of cosmic ray research gathered to discuss topics ranging from the cosmological significance of large extensive air showers to recent measurements of the cosmic ray intensity in deep Canadian mines.

The theme of the Conference was two-fold: the cosmic and geophysical significance of cosmic ray measurements, and the nuclear physics of single-particle interactions. The Conference was divided into short sessions in which an invited review paper of 45 min. was followed by a number of 10-min. papers.

The first session was devoted to a discussion of interactions in the energy-range 1–100 GeV. Recent results with machines were considered at the lower end of the energy region and the results of cosmic ray proton experiments for the remainder. Experimentally, several features appear to be clear: the inelasticity of proton interactions with light elements does not vary greatly with proton energy; the value is about 60 per cent, and the rate of production of heavy mesons increases slowly with increasing energy. Also clear is the inadequacy of the various theories of meson production—Fermi, Landau, etc.—to account for the observed angular distribution of meson production in the centre of mass system. The experimental results would be consistent with the isotropic emission of mesons from two centres moving away from the collision more slowly than do the original nucleons, but there does not seem to be any theoretical justification for this model. Since it is unlikely that machines capable of accelerating protons to energies much above 20 GeV. will be constructed in the next few years, attention is naturally focused on the cosmic ray experiments in this energy region. At present the interpretation of the experiments is difficult: the momenta of the primary protons are not measured, in fact, often the directions are not determined, and the secondary momenta are too high for accurate measurements. This point was well brought out in the first contribution, which described the results of a design study for an experiment in which accurate measurements of the parameters of the interaction would be possible. Such an experiment would be expensive by cosmic ray standards but not by machine standards ; it is perhaps within the scope of a collaborate university venture.

In the second session the energy-range was extended to 100,000 GeV. Most of the information in this region has come from studies of the so-called 'jets' observed in nuclear emulsions exposed in high-flying aircraft and balloons. The number of particles produced in the cascade resulting from some of the very energetic nuclear encounters (above a few thousand GeV.) is so great that the events can be seen in the processed emulsion with the naked eye. At these high energies there is quite copious production of particles heavier than the pion, for example, the ratio of the charged heavy particles to all charged particles is 18 ± 5 per cent. Another important result is that the interaction length of the secondaries of mean energy around 200 GeV. is very close to that found for pions and protons in the region of a few GeV. This result has important implications in the study of the development of the various components of the cosmic radiation through the atmosphere. Thus, for example, the pion flux is subject to the competing mechanisms of decay and interaction and is consequently sensitive to the value of the interaction length.

The energy-range under review was extended still further in the next session when various aspects of extensive air showers were discussed. The cosmological aspect is of supreme interest, bearing as it does on the origin of the cosmic radiation. The situation here has not changed over the past few years: the search for anisotropies in the primary cosmic radiation at energies up to 10^{18} eV. or so has still failed to produce statistically significant results. The need at present is for an order of magnitude increase in the size of the detecting arrays for extensive shower studies, and at least two such projects are afoot at the present time. Even with improved experimentation, however, the interpretation of the sea-level shower data is not straightforward. The electron component, which is traditionally measured, is subject to considerable fluctuations, arising in the main from the fluctuation in the height of the first primary proton interaction. For this reason attention is now being turned to the muon component for which the fluctuations are smaller, although difficulty is encountered due to the particle densities being considerably lower, at least for distances less than a few hundred metres from the shower core. The session finished with the description of a number of new techniques by which detectors of the necessary large area could be constructed.

The current interest in the International Geophysical Year was reflected by a session on cosmic rays and solar–terrestrial relations. A considerable mass of data is accumulating on this subject from measurements or the variation with time of the various components, particularly the neutron component. The spectacular increases in intensity during the big solar flares has emphasized the part played by the Sun in producing low-energy cosmic rays. There is as yet no completely satisfactory explanation of the way in which these particles are accelerated or of the modulation of the primary cosmic rays by the Sun's magnetic field, but the result of the analysis of the very detailed International Geophysical Year results may lead to a considerable advance.

The interaction of the primary cosmic rays with the Earth's magnetic field was discussed by speakers from the Imperial College of Science and Technology. Experiments over the past few years have shown that the position of the cosmic ray equator, that is, the locus of the minimum of the cosmic ray intensity, is not consistent with the magnetic equator based on an eccentric dipole field. The disagreement amounts to a westward displacement in longitude of about 45°, and an attractive explanation was the bending of the lines of force from the rotating Earth by a surrounding region of highly ionized interplanetary matter. The Imperial College group has shown, however, that the dipole approximation is not a good one even at the distance from the Earth where most of the magnetic deflexion of the primary cosmic ray takes place. A more accurate treatment of the effect of the Earth's field taking into account the various magnetic anomalies removes the discrepancy between the respective equators.

The development of the muon component through the atmosphere and below ground occupied the next session. It was demonstrated that measurements on the sea-level muon flux give information on the multiplicity and mass spectrum of the products of primary interactions. Comparison with the underground depth–intensity relation gives information on the energy losses of muons of energy up to 1,000 GeV.—information that is not available from other measurements.

With the introduction of new techniques of measurement, in particular the neon flash-tube of Conversi, and the consequent ease of measurement of high particle momenta, there has been something of a revival of muon spectrum measurements. Large magnetic spectrographs have been completed recently at sea-level at Cornell and Durham, and a number of smaller instruments are under construction for measurements of muon spectra in inclined directions and at various depths underground. The next few years should see significant advances in this subject.

The interactions of individual fast muons with nuclei were also discussed in this session. This interaction is via the flux of virtual photons accompanying the muon, and recent advances have been made both in the theoretical study and the experimental determination of cross-sections and other parameters of the interactions. Although there is still some slight doubt as to the way in which the original Williams–Weizsäcker treatment of the virtual photon flux is to be modified for ultra high-energy muons, the main features, such as the angular deflexions of the interacting muons and the multiplicity of the pion secondaries, are understood. The importance of these measurements lies in the fact that what is being studied is effectively the interaction of photons of energies much above those available from artificial sources. The most that can be said about the variation of photo-nuclear cross-section with energy at the moment is that there is no strong evidence to suggest a cross-section varying very much from 10^{-28} cm.^{2}/nucleon between 1 and 40 GeV.

The last session was devoted to a discussion of the results of recent experiments on low-energy muons and electrons. The general impression that emerges from studies of muon decay and capture is that whereas the decay process is fairly well understood there are still some uncertainties in the explanation of the observed capture-rates. The discussion of electron interactions centred mainly around the Stanford work on nuclear sizes. One of the most interesting results of this work is the small size of the electrostatic charge core of the neutron. The interpretation of this result is not clear and the confirmation or otherwise of this result by more accurate experiments is awaited.

The conclusions to be drawn from this rather overworked Conference appear to be that there is still much to be learned about virtually every aspect of the subject. It would appear that for some time to come cosmic ray experiments are likely to be the only source of knowledge on nuclear processes at energies greater than 20 GeV. A. W. Wolfendale

COMMONWEALTH UNIVERSITIES' CONGRESS, 1958

THE Eighth Quinquennial Congress of the Universities of the Commonwealth, the first to be held outside the United Kingdom, was held in Montreal during the first five days of September. The Congress had been preceded by a smaller conference of executive heads of the Commonwealth Universities, held in the University of Toronto during the previous week. At that conference, some useful exchanges of view took place on some current university problems. The Montreal Congress was attended by more than 400 delegates and guests, many of them accompanied by their wives. Among the guests were some twenty-four American university presidents and the members of the administrative board of the International Association of Universities. The Congress was probably the most comprehensive gathering of representatives of the university world of the British Commonwealth and the United States which has yet taken place. There was consensus of opinion that never before had so much mutual understanding been achieved, both by the sessions of the Congress and otherwise, of the general and detailed patterns of university institutions in the countries represented at the Congress. Most of the Congress sessions were held at McGill University, although one session was held in the University of Montreal. Both universities provided accommodation and lavish hospitality for the delegates and their wives.

At the opening ceremony on September 1, the delegates and guests were welcomed by Dr. Andrew Stewart, president of the University of Alberta, in his dual capacities of chairman of the Association of Universities of the British Commonwealth and president of the National Conference of Canadian Universities. The Congress was formally opened by the Right Hon. Vincent Massey, governor-general of Canada, who warned that universities to-day tread a dangerous path in increasingly accepting government money, offered because they are doing things that government wants done. "The intellectual duty of the university to remain free is," he insisted, "greater now than ever, and more difficult than ever before." The opening address of the Congress, on "Expanding Education", was then delivered by Sir Hector Hetherington, principal of the University of Glasgow, who described himself as the veteran who had attended all but one of the previous seven congresses. He referred to two new elements in the expansion of university education in all the countries represented at the Congress—that the required rate of expansion is abnormally high, and that what is wanted is not a general all-round expansion but one designed to take effect mainly in one direction, science and applied science. Sir Hector posed no new problems and proffered no new solutions. He explained how the present situation had come about and what steps had been taken, and were being taken, to deal with it. He propounded the principles which, in his view, needed to be kept in mind in the expansion of professional education, if it were not to become mere vocational training, and he urged the value of keeping the humanities, together with science, at the centre of the university stage.

The first ordinary session of the Congress, on September 2, was devoted to a discussion of "Who should govern University Policy ?" In this and subsequent sessions the speakers tended to outline the procedures and philosophies applicable to their own countries, and this brought to light rather unexpected degrees of divergence but there was very little attempt at synthesis ; and the Congress formulated no general conclusions. The first speaker, Dr. V. C. Fowke (Saskatchewan), was concerned primarily with internal controls over university policy, and dealt specifically with the Canadian universities. He directed attention to two diametrically opposed concepts of university government : one, that a university ought to be a self-governing community of scholars, and the other, that it is a business enterprise which is best governed by typically corporation methods. The written constitutions of the Canadian universities tend strongly towards the latter. The allocation of funds, the determination of priorities and the selection of personnel are all the responsibilities of lay boards which have no academic representation. Usage, however, makes wide concessions to self-government and it is the academic staff who determine whom they shall teach and how they shall teach, with control of examinations. They cannot have these controls without an effective voice in financial allocations. Chancellor L. A. Kimpton (Chicago), the second opening speaker, elected to defend the American practice of giving the university administrator more power, perhaps more dignity, than is usually accorded him in the British tradition. He pointed out that most lay boards in the American universities have only fiscal interest and power, and he claimed that the administrator should have an important role in determining policy because of the inherent limitations of the faculty. The defence of academic freedom is a matter to be undertaken by the university president, whose task will be the education of the public. Other functions of the president, in Dr. Kimpton's view, are: (*a*) the protection of the academic community from pressures which might make the university unbalanced; (*b*) to take strong remedial action with an inefficient or incompetent department, and (*c*) the raising of funds. None of these functions can be exercised effectively by academic bodies. In the ensuing discussion, Dr. T. Alty (Rhodes University, South Africa), doubted whether the principal or vice-chancellor of a Commonwealth university had functions very different from those of the American university president. He is a key figure and must exercise an important influence on university policy. Interpretation of the university to the public is not a function of the academic staff, and is best done by members of a lay governing body. But the determination of policy should be a co-operative enterprise; academic bodies, lay boards and university president all taking a share. Sir Keith Murray (University Grants Committee), while believing in self-government, stressed the need for lay participation, in which he saw four major advantages. The lay members can bring to the university the advantages of 'corporation' methods, they can exercise a semi-judicial function and help to solve otherwise insoluble problems, they can lighten the administrative load of the academic members, and they can help to promote public confidence, especially important as universities become increasingly dependent on public funds. Other contributions were made by Sir Charles Morris (Leeds), who agreed about the value of the lay members, but thought that the modern university should give the head of an academic department an important share in policy-making; by Prof. N. K. Sidhanta (Calcutta), who directed attention to the special problems of the 35 Indian universities, with some 800,000 students, of whom more than 700,000 were taught in the numerous affiliated colleges; and by Mr. A. Hakim (East Pakistan), Prof. K. E. Bullen (Sydney), Dr. C. H. Rautenbach (Pretoria), Prof. D. V. Cowen (Cape Town), President Grayson Kirk (Columbia), Mr. W. H. Gillespie (Canterbury Agricultural College), and Dr. H. B. Thom (Stellenbosch), who discussed the respective functions of the principal, the academic staff and the lay members in the determination of policy. There was a general appreciation of the valuable role of the lay member.

At the second session of the Congress Prof. J. F. Baker (Cambridge) opened a discussion on "Engineering Education, and its Place in the University". He gave a general survey of the engineering tripos course at Cambridge, an unspecialized course covering all the main branches of engineering science conducted in a single department of engineering. His satisfaction with the arrangements was not shared by President G. P. Harnwell (Pennsylvania) in respect of engineering education in the United States. Engineering was a latecomer among the academic disciplines; the lack of differentiation between professionalism and technicianism had operated to its disadvantage, and had hindered its recognition. Moreover, the greater emoluments and prestige of the practising engineer had adversely affected recruitment of academic staff. He thought that the closest possible association of engineering education with the universities should be maintained, and was unimpressed by the Soviet system of professional education in specialized institutes. President L. A. DuBridge (California Institute of Technology) asked where el
university would one have enginee
and subsequent speakers were almo
in agreement, giving various reasons, s
affinity with other sciences, the liber
of a background of other academic
conversely, the beneficial influence
engineering on other faculties. A
was sounded by Dr. B. V. Bowd
College of Science and Technology),
that the industrial revolution was lar
who had never been to a university.
attention to the dual system of engine
in the United Kingdom (in universit
technology), and developed the doctrin
ing is not only a mathematical science
with design playing an important par
the engineer. Mr. A. Hakim (East Pa
to the difficulty of staff recruitment,
which was echoed by other Asian sp
sessions, for Western assistance, b
secondment or otherwise.

The complementary theme of "Me
and its Place in the University" was
session on September 3. The openi
Lord Adrian (Cambridge), who remind
that medical schools have often gr
contact with universities, and that
have their hospital work to prev
becoming too narrow-minded. He
segregation in the pre-clinical period c
by giving more emphasis to general s
which could be shared with other stud
Soper (Otago) and Sir Nicholas At
both saw great advantage in th
of medical students and those of othe
Soper thought it even more impo
staff should intermingle. Sir D
(Aberdeen) challenged the view s
that the medical curriculum is enti
and suggested that medicine is in
humanizing training available in a
university would be much the poore
faculty were removed. His views
by most subsequent speakers, repre
in Australia, Canada, India, Malaya,
United Kingdom. Various aspects
curriculum were discussed, and it wa
postgraduate studies tend to be negle

At a private session on September
discussed some current problems in
universities, especially those in Cana
and South Africa. The final session,
was concerned with "The Establis
Universities". Dr. D. W. Logan (L
the part which had been played
degree system of the University of
development of the new British un
tions, both at home and in the unde
of the Commonwealth. He directed
merits and defects of the system, w
was unlikely to continue as the no
The principal safeguards of the qualit
institutions would be the externa
appointments and examinations.
Morrill (Minnesota) pointed out tha
Canada and the United States deriv
of higher learning from the British
policies and procedures for the estab
universities in both countries repres
departure from the British precedent

had responded rapidly to the indigenous educational demands of fast-growing frontier societies and populations. "Universities are at once the catalysts and creations of a changing society." Several speakers agreed with Dr. Logan about the need in present circumstances to establish new universities. An impressive account of the principles adopted in the institution and development of seven new university institutions in the British Colonies was given by Dr. W. Adams (Rhodesia and Nyasaland). Lord Sinclair (Bristol) thought that the ultimate success of the Rhodesian experiment was of great importance to the whole British Commonwealth. Dr. C. H. Wilson (Leicester) stressed that two conditions were needed to warrant the foundation of new universities —local initiative and support, and a demand from prospective students. Dr. R. B. Madgwick (New England, N.S.W.) emphasized the weaknesses of a system of tutelage by existing universities. Dr. T. M. Advani (Bombay) referred to the remarkable demand for education in India after independence. The desire for knowledge is great, but the desire for acquiring degrees even greater. In referring to the service which universities provide for the community the Hon. P. M. Sherlock (West Indies) pointed out that the university may become a powerful competitor for limited resources. Dr. N. A. Mackenzie (British Columbia) asked whether, when it is difficult to obtain staff of adequate quality for existing institutions, it is wise to found new ones, and Dr. V. K. R. V. Rao (Delhi), after pleading for a national organization to lay down the principles on which a new institution should be established, asked: "What is a university ?" At this stage these questions proved too difficult, and the Congress disbanded.

After the Congress, executive heads of Commonwealth universities and their wives paid a week-end visit to Washington and Philadelphia as guests of the Association of American Universities. In Washington they had the honour of being received by President Eisenhower at the White House, and of being addressed by Mr. Justice Frankfurter in the Supreme Court. The other delegates were entertained by Laval University in Quebec City. After the week-end, most of the delegates set off on one or other of eleven tours for which the transport costs were provided by a generous grant from the Carnegie Corporation of New York. Members of each party were thus enabled to visit some four or five universities in Canada and the United States, hospitality being provided by the universities concerned. For many of the delegates this was the most stimulating and rewarding part of their mission, as it allowed more intimate personal contacts than had been possible at the large Congress and gave a revealing insight into the workings of a variety of university institutions in the New World.

J. W. COOK

THE WORLD LAND USE SURVEY

THE World Land Use Survey owes its inspiration very largely to Prof. L. Dudley Stamp and his great achievement in carrying through in pre-war days the work and organization of the Land Utilisation Survey of Britain. A Commission, appointed at the International Geographical Congress held at Lisbon in 1949, was very impressed by the urgency of the problems of world population and world food supply and considered that "present factual knowledge is inadequate to serve as a proper foundation for schemes of improvement and development, especially in those areas which are commonly regarded as 'underdeveloped' ". It proposed, therefore, a World Land Use Survey that would record the present use of land in all parts of the world on a uniform system of classification and notation, basing the maps on field-work together with the interpretation of other material such as air photographs. It hoped that a series of maps on the scale of 1 : 1,000,000 might be published together with explanatory memoirs that would help in the understanding of the maps.

The work in different parts of the world has met with varying success. Some pilot surveys suggested that, elaborate though the land-use classification was, it often required further amplification, and sometimes modification. Aspects of the work have been taken up by Government departments, such as the Directorate of Overseas Surveys which has developed most usefully the interpretation of air photographs as a source of land-use data.

Some preliminary results are becoming available through the issuing of maps and reports. A map of Cyprus at a scale of 1 : 250,000 was published in 1956[1]. It was based on the stereoscopic examination of 10,000 photographs and was prepared in the Department of Geography at the London School of Economics under the direction of R. R. Rawson and K. R. Sealy. The first of the Survey's 'Occasional Papers', "Land Use Studies in the Transvaal Lowland", by Dr. Monica M. Cole, of the University College of North Staffordshire and formerly of the University of the Witwatersrand, also appeared in 1956[2]. It was a "contribution to the study of the opportunities and difficulties inherent in the savannah environment" and laid emphasis upon the many environmental factors that challenged the area's agricultural development.

Recently, the Survey has published the first of its Regional Monographs, "A Survey of Land Use in Hong Kong and the New Territories", by Dr. Thomas R. Tregear, lecturer in geography in the University of Hong Kong[3]. The volume includes a coloured land-use map at a scale of 1 : 80,000 distinguishing eight types of land use: woodland, scrub, rough grassland, 'badlands' that are heavily eroded, arable, swamp, houses with gardens, and built-up areas, including camps, cemeteries and other land that is agriculturally unproductive. Hong Kong illustrates in a special way the necessity for the fullest possible use of such land as is available, with its great population (estimated at between 2 and 2½ millions and increasing at more than 70,000 per annum) crowded into a mere 400 square miles of the Earth's surface. There is the sharp contrast between the crowded urban areas of Hong Kong and Kowloon and the rural districts of the New Territories. Serious problems arise from the mountainous nature of much of the area and from the heavy, often torrential, rainfall which is largely responsible for the soil erosion that has created the 'badlands' of the open hillsides.

Dr. Tregear has tried to bring together the basic data necessary for the use of planners and administrators, and to indicate the sources from which fuller information can be obtained. His is a factual survey, a record of things as they are, not a forecast of possible developments nor a catalogue of suggested remedies for the territory's land-use problems. This is exactly as it should be and it is indeed the justification for all land-use surveys. They may be difficult to carry out and they may sometimes seem very wasteful of time and energy ; yet without them there can be no precise and objective assessment of land use as it can be observed to-day. Subjective judgments, wishful thinking and intelligent anticipation are all specifically excluded from the purpose of the World Land Use Survey.

In essence, Dr. Tregear's monograph is an exposition and elaboration of the land-use map prepared. At times the literary style is weak, and occasionally the text becomes little more than a series of notes. A few of the diagrams are disappointing because they cannot be read easily or have been excessively reduced. Sometimes Dr. Tregear might have emphasized more those relationships of physical and human phenomena that geographers claim as a special part of their field. There may well be monographs with a rather more penetrating analysis later in this series. Nevertheless, the volume deserves a welcome by geographers and others both for its own worth and as an indication of what may be expected for other areas in the future. It is a sign that the World Land Use Survey has passed beyond the talking and planning stages and, in some countries at least, beyond the field-work to the point where maps and reports are being produced. Clearly the editor, Prof. Stamp, who has just retired from his chair in the University of London, is going to be as active as ever in the years to come. We can, therefore, anticipate a series of regional monographs for the world that will be comparable in conception, content and importance to the well-known County Reports of the Land Utilisation Survey of Britain.

Robert W. Steel

[1] Rawson, R. R., and Sealy, K. R., "Land Use Map of Cyprus"' 35 in. × 22 in. (Bude : Geographical Publications, Ltd., 1956.) 3*s*.

[2] Cole, M. M., "Land Use Studies in the Transvaal Lowland" (World Land Use Survey : Occasional Paper 1). Pp. 41+37 figs. (Bude : Geographical Publications, Ltd., 1956.) 5*s*.

[3] Tregear, T. R., "A Survey of Land Use in Hong Kong and the New Territories". (The World Land Use Survey : Monograph 1.) Pp. v+75+1 map. (Hong Kong : Hong Kong University Press ; Bude : Geographical Publications, Ltd., 1958. Distributed outside Hong Kong by Macmillan and Co., Ltd.) 12*s*. 6*d*.

THE FRESHWATER BIOLOGICAL ASSOCIATION

BESIDES details of the administration, organization and state of the finances of the Freshwater Biological Association for 1957–58, the twenty-sixth annual report contains a statement by the Director on the scientific work of the staff.

In the chemistry section analyses of algae have shown that cobalt, copper and zinc are present in the plant tissues in amounts the ratios of which are similar to those of their concentrations in the environment, a fact which suggests that the uptake of such elements by algae may be governed rather by their concentrations in the surrounding water than by any physiological needs of the plant.

Earlier work on the acid waters of blanket bogs in the Pennines and of bog lakes in Nova Scotia suggested that both owed their acidity to sulphuric acid. Dr. E. Graham has now extended these studies to bog waters elsewhere in Britain and in less-oceanic sites in Poland with similar results. Since sulphuric acid also seems to cause the acidity of the soil solutions extracted from heavily leached mor humus layers overlying podzolic soils in Lake District oak woods, it is probably to be regarded as an important agent in soil leaching. While in Britain it comes largely from atmospheric pollution brought down in rain, there is evidence that it is also produced by the breakdown of organic sulphur compounds in the soil ; it may therefore be important in unpolluted areas also.

Continuing his observations on the fluctuations in numbers of the smaller nannoplankton, Dr. J. W. G. Lund finds a clear difference between the periodicity of the very small green algae in the surface waters of Windermere, Esthwaite Water and Blelham Tarn and that of the larger species. Thus, large populations of the small forms have been observed in late winter and early spring. It will, however, be necessary to continue observations over several years to determine whether this happens regularly.

Work on the polycentric chytrids which occur in the reed beds of Windermere has been continued by Dr. L. G. Willoughby, who is making a comparative study of eight isolates of *Cladochytrium replicatum*. So far, particular attention has been paid to growth-rates and fruiting (that is, zoosporangium formation) on agar. One of the isolates has been uniformly sterile under all conditions, while another has only rarely formed zoosporangia. Two further isolates of the eight can be segregated not only on purely morphological grounds, but also because the rate of linear growth on agar is consistently high. The effect of light on growth and fruiting in this fungus has been investigated. Light is not essential for pigment and hence zoosporangium formation, and total growth, as measured by the increase in colony diameter on agar, is independent of this factor. It seems clear, however, that fruiting is generally greater in light than in the dark, the effect being particularly noticeable in the isolates with high fruiting capacities.

A further study has been made of the influence of the container on the rate at which bacteria multiply in samples of lake water stored in the laboratory. This has been extended to cover polyethylene and nylon containers as well as those of silica, 'Pyrex' and soda-glass. The conclusion reached previously that silica provided the least 'active' surface for bacterial growth was confirmed ; the others follow in the order 'Pyrex', soda-glass, polyethylene up to nylon, which stimulates the largest bacterial growths. It appears that the surface properties of polyethylene and nylon in particular facilitate the supply of something the bacteria need, whereas silica has no such property, regardless of the type of water, the temperature, or of whether the containers are stationary or shaken. This is borne out by the discovery that in experiments using a constant circulation of water, considerable multiplication of bacteria took place wherever the liquid remained in contact with polyethylene or nylon connecting tubes. These results may have direct practical importance on industrial process problems, where polyethylene pipes become blocked by masses of slime-forming bacteria attached to the walls, and in the storage of non-sterile solutions in containers made of these materials.

The use of opercular bones to estimate the age and past growth of pike has been further investigated by Dr. Winifred Frost and Miss Charlotte Kipling, who concluded last year that growth can be calculated accurately by simple proportion from measurements of the annual rings, making an arbitrary choice by inspection of a centre from which to make the measurements. Since the rings near the centre are not always clearly visible, the method does not give reliable estimates of growth in the early years of life. This difficulty has been overcome by the use of theoretical growth-tables derived from Ford's growth formula, using data from Windermere calculated for slow-, medium-, fast- and very fast-growing fish for the two sexes separately. By comparing the growth in later years of any individual fish with these tables, it is usually possible to assign it to one of the growth-rate categories. This makes it possible to infer its true age and so to decide whether the first discernible ring represents its first, second or third winter.

D. F. Westlake has measured the rate of production of oxygen by *Ranunculus* spp. in a closed, static system, at various light intensities. The highest gross rate of oxygen production found for light-saturated plants was about 10 mgm. of oxygen hr./gm. (dry weight) at 15° C. Light-saturation was approached at 10,000 lux, and both this and the maximum rate of oxygen production are lower than generally reported in the literature on higher plants. Possibly this is the result of using static conditions for the experiments, and apparatus for determining oxygen production in flowing conditions is being developed.

MECHANICAL ENGINEERING RESEARCH LABORATORY

REPORT FOR 1957

THE report on the work of the Mechanical Engineering Research Laboratory for 1957* makes fascinating reading, and contains much that will interest any engineer and many physicists.

The chairman of the Engineering Research Board directs attention in his report to the difficulty of getting the results of the Laboratory's work both disseminated and applied. Most engineering scientists have yet to learn that a paper which may lead in due course to scientific honour is unlikely to be understood by many practising engineers, however high their theoretical attainments; the work must also be published as a straightforward physical description, written in lucid English and devoid of mathematics if it is to be read and applied. Sir Charles Inglis used to state this truth regularly in his lectures; few have learned the lesson.

The proportion of scientific and experimental staff is 160 out of a total of 444. This seems high. Does the Laboratory suffer from the difficulty common in Government and university laboratories of being hamstrung financially in providing adequate ancillary and office staff?

In recommending a rapid expansion of the Laboratory, the problem of how it, the universities and the colleges of advanced technology are all to be staffed must arise. In Germany, most of the work similar to that done at the Mechanical Engineering Research Laboratory is done in institutes of the Technische Hochschulen. Might it not be better to give the colleges of advanced technology similar institutes?

While it is clear why some of the research, both fundamental and applied, is being done nationally, it is surprising to find that fundamental work on greases has not already been undertaken on an adequate scale by private industry. When such gaps are found, is it not desirable that they should be investigated where the staff concerned can also be available for part-time teaching?

Nevertheless, the report describes the development of fine facilities and the accomplishment of much excellent work. Many firms should read it and send members of their staff to see what is being done.

D. B. WELBOURN

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* Department of Scientific and Industrial Research. Mechanical Engineering Research 1957: Report of the Mechanical Engineering Research Board, with the Report of the Director of Mechanical Engineering Research. Pp. iv+63+4 plates. (London: H.M. Stationery Office, 1958.) 4s. 6d. net.

TILT CRITERIA AND DIRECTION OF ROTATION OF SPIRAL GALAXIES

G. DE VAUCOULEURS has a paper with the above title in the *Astrophysical Journal*, 127, 2; March 1958, in which he presents a review of the observational evidence on the direction of rotation of the spiral pattern in ordinary and barred spirals. A growing body of evidence suggests that the formation of spiral structure is governed by the large-scale magnetic and hydrodynamical properties of the interstellar medium in rotating galaxies, and according to current ideas, dust or 'smoke' particles may form out of the gaseous medium and induce the condensation of gas clouds into stars or groups of stars. The author of the paper has discussed the morphology of spiral structure and its bearing on the large-scale instantaneous distribution of gas and dust in galaxies (*Hand. Phys.*, 53), and in the present paper he deals with the systematic motion of the interstellar substratum on the largest scale in a galaxy, in other words, with the general rotation of the spiral pattern. The previous investigations of those who have devoted their attention to this subject—Baade, Hubble, Lindblad, Stebbins, Zwicky and others—are referred to, and the reasons for the divergences in the interpretations are analysed. The discussion is recapitulated in Table 1, p. 499, which consists of eleven columns (the symbols used in these are explained at the end of the table and also on the previous page) and the conclusions are briefly as follows.

Comparing this table with similar tables of Hubble published in 1943 it appears that of the fifteen objects in his Table 1, "Well Observed Nebulæ", six are in common with the present discussion, and the conclusion that the arms are trailing in the rotation appears unequivocally confirmed by one or several of the primary or secondary criteria. Of the eight objects in Hubble's Table II, "Doubtful Cases", five are in common and three have been removed from the doubtful class by the application of one or several of the same criteria. *NGC* 5005, which was doubtful only in respect to the sense of spectroscopic rotation given by Slipher, has now been confirmed by Mayall, and the last one (*NGC* 4594) is indecisive. It is pointed out in Appendix I, however, that in 1951 Lindblad attempted to unravel the direction of its spiral pattern by means of a geometric restoration in the plane of the spiral of the distribution of bright knots measured on a photograph in ultra-violet light with the 200-in. reflector. Fig. 9*a*—Lindblad's interpretation—is not unambiguous, and an alternative interpretation (*b*) of the distribution appears at least as plausible,
direction for the spi
arms. From addit
seems clear that alt
case, nevertheless
interpretation *b* rat

NGC 5746, Fig. 1
is a "true spindle"
similar to *NGC* 45
which is the near s
direction of the s
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cluded that "the
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VISUAL PIGMENTS OF THE OCTOPUS A

By PAUL K. BROWN and PATRICIA S. B

Biological Laboratories of Harvard University, Cambridge, Mass., and

THE first molluscan visual system to be examined chemically was that of the common squid, *Loligo pealii*. This animal possesses a rhodopsin comparable with that found in vertebrate rods, composed of neo-b retinene joined to the protein, opsin[1,2]; but under physiological conditions, squid rhodopsin engages in a more limited series of reactions than occur in the vertebrate retina. In vertebrate rods, rhodopsin bleaches in the light, over the transient intermediates lumi- and meta-rhodopsin, to a mixture of retinene and opsin; then retinene is reduced to vitamin A. In the squid retina, the little vitamin A that is present seems to take no immediate part in the visual processes[3]; and light does not normally bleach rhodopsin, but converts it to metarhodopsin. Vertebrate metarhodopsin is highly unstable, hydrolysing rapidly to retinene and opsin; but squid metarhodopsin is stable, the retinene remaining attached as chromophore to opsin. The change from rhodopsin to metarhodopsin involves only the isomerization by light of the chromophore retinene from the neo-b configuration (11-*cis*) to all-*trans*. Light also causes the reverse isomerization, from all-*trans* to neo-b. That is, in the squid retina light brings into a steady state the system:

$$\text{rhodopsin} \overset{\text{light}}{\rightleftharpoons} \text{metarhodopsin} \quad \text{(ref. 2)}$$

This pair of reactions, which only introduces the rhodopsin system in a vertebrate, is the entire system of the squid.

A period spent at the Stazione Zoologica in Naples afforded us an opportunity of working on the visual systems of the octopus (*Octopus vulgaris*) and cuttlefish (*Sepia officinalis*). The animals were dark-adapted 8–10 hr., and the retinas dissected out under red light, and frozen. After thawing, the tissue was ground in a cold mortar in 40 per cent sucrose (w/v). The suspension of tissue in a centrifuge tube was covered with
and centrifuged a
'rods' collected in
and buffer, and w
residual tissue wa
as before, and r
suspensions of rod
diluted with neut
mented in the ce
in cold 35 per ce
buffer, re-centrifu
interface. The ro
volume of 1 *M* di
and again collecte
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1 ml. of 2 per cen
these procedures
1·0 ml., $E_{\text{max.}}$ 0·
$E_{\text{max.}}$ 0·49. The
than this; much
ations to achieve

Both extracts
of measurements.
and 2, and in Tab

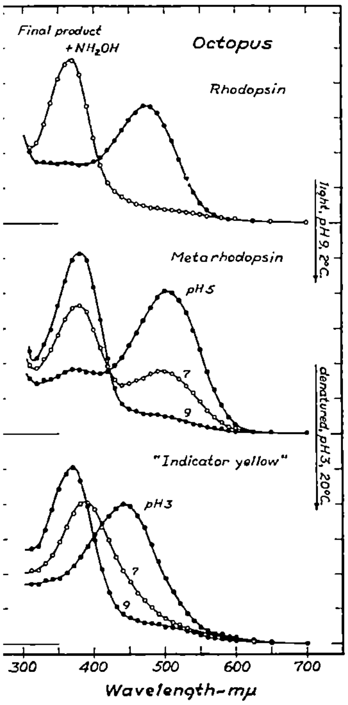
	Octo
	λma (m
Rhodopsin	47
Alkaline metarhodopsin	38
Acid metarhodopsin	50
Alkaline indicator yellow	36
Acid indicator yellow	44

on spectrum of *Sepia* rhodopsin is like with $\lambda_{\max}$ 492 mμ. *Octopus* rhodop- ıch shorter wave-lengths, with $\lambda_{\max}$. orange rather than red in colour. In resembles the rhodopsins of deep sea oth cephalopod rhodopsins a small nt at about 360 mμ.

to light at *p*H 9 and 2° C., *Sepia* and psins were converted to the correspond- psins. The spectra of these substances, H 9, 7 and 5, showed that they are *p*H in *Loligo*[2]. In alkaline solution, the s of all three organisms have $\lambda_{\max}$. In acid solution these substances coloured, apparently through adding a of the acid metarhodopsins are a little ch organism (Table 1). These changes ersible. The absorption spectra at all hibit a common or isosbestic point, they represent stoichiometric inter- tween a specific initial and a specific his appears to involve, as in *Loligo*, the

sin $+ \mathrm{H}^+ \rightleftharpoons$ metarhodopsin$-\mathrm{H}^+$

cephalopods of the $\lambda_{\max}$ of acid meta- at longer wave-lengths than that of d its extinction is also higher. As a posing these rhodopsins to light, they ur rather than bleach. *Octopus* presents of this condition; the $\lambda_{\max}$ of its



pigments of the octopus. Top, right: rhodopsin, liddle row: metarhodopsin, formed by irradiating is is a *p*H indicator, going reversibly between an $\lambda_{\max}$ 380 mμ) and an acid form ($\lambda_{\max}$ 503 mμ), her extinction than rhodopsin. Bottom row: the has been converted to 'indicator yellow' by h acid. This changes in colour with *p*H, going ted Schiff base in acid solution ($\lambda_{\max}$ 443 mμ) to a retinene and denatured opsin in neutral solution , and to an indiscriminate mixture of Schiff base en retinene and opsin in alkaline solution ($\lambda_{\max}$. e end of these procedures, the product was treated mine to convert all retinene to retinene oxime; sulting spectrum is shown at the top, left

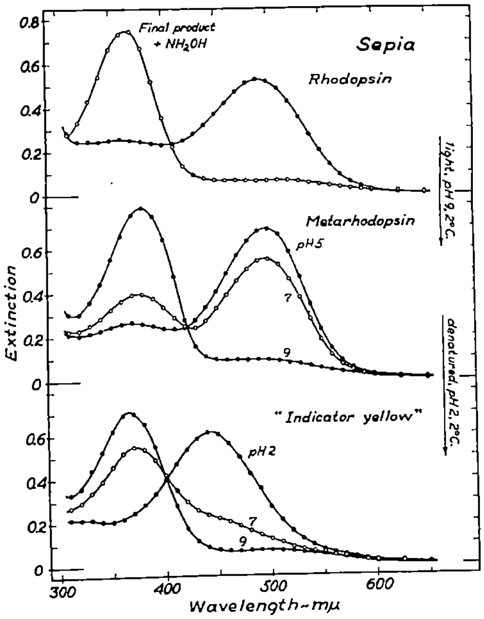


Fig. 2. Visual pigment of the cuttlefish. Top, right: rhodopsin ($\lambda_{\max}$ 492 mμ). Middle row: metarhodopsin at *p*H 5, 7 and 9. Bottom row: 'indicator yellow' at *p*H 2, 7 and 9. In this instance it appears that the acid denaturation of metarhodopsin was not wholly completed, and this accounts for some distortion of the spectra of indicator yellow, particularly at *p*H 7. The appearance of a common or isosbestic point in the spectra of indicator yellow is also a fortuitous result of this distortion. At the end of these procedures the product was treated with hydroxylamine to convert retinene to retinene oxime; the resulting spectrum is shown at the top, left

metarhodopsin is 28 mμ longer than that of rhodopsin, so that when *Octopus* rhodopsin is irradiated it changes in colour from orange to red.

In rhodopsin the aldehyde group of retinene appears to be combined with a specific amino-group of opsin in a Schiff base linkage:

$$\mathrm{C_{19}H_{27}CHO + H_2N\text{-}opsin} \rightarrow \mathrm{C_{19}H_{27}CH{=}N\text{-}opsin + H_2O}$$

To explain the colour, it is assumed that this has added a proton, the charge of which induces a greatly increased resonance in the conjugated system of retinene: $\mathrm{C_{19}H_{27}CH{=}NH^{+}\text{-}opsin}$; and supposes also that a close steric fit between the hydrocarbon portion of the retinene molecule and the protein, permitting a high degree of interaction between the two, further enhances the resonance[6]. In metarhodopsin (acid form), much the same situation obtains, except that retinene has gone from the neo-b to the all-*trans* configuration; this also appears to be a protonated Schiff base, its spectrum still enhanced by the steric fit between retinene and opsin[2].

The metarhodopsins were now denatured by being brought to a high acidity (*p*H 2–3). We shall call this product 'indicator yellow'. With the denaturation of opsin, the fit between it and all-*trans* retinene is lost, with a corresponding loss of colour. The $\lambda_{\max}$ falls to 443 mμ, the position found in a variety of model Schiff bases of retinene when acidified[7]. The retinene is probably still attached to the original amino-group (the "N-retinylidene opsin" of Morton and Pitt, yet with denatured opsin); but on neutralization of the solution, it hydrolyses off, to yield free retinene and denatured opsin[8]. The $\lambda_{\max}$ of these preparations, brought to *p*H 7, is therefore that of free retinene, about 385 mμ. (In Fig. 2 this spectrum is distorted by the presence of a residue of metarhodopsin.) On making such a solution alkaline (*p*H 9), retinene recombines with amino-groups, not only at the original site, but indiscriminately, to form a variety of Schiff base linkages with $\lambda_{\max.}$ 367 mμ (ref. 7). These changes are thereafter reversible.

At the close of these procedures, hydroxylamine was added to the solutions, converting all the retinene present to retinene oxime ($C_{19}H_{27}CH{=}NOH$). The resulting spectra are shown at the top (left) of Figs. 1 and 2. From the relative extinctions of rhodopsin and the retinene oxime derived from it, and the known molar extinction ($\varepsilon_{\max.}$) of retinene oxime (51,600), the $\varepsilon_{\max.}$ of the rhodopsins can be computed (Table 1)[8]. For both *Sepia* and *Octopus* this comes out to be about 37,000, slightly lower, though perhaps not significantly, than cattle or *Loligo* rhodopsin (40,600)[9].

In summary, these measurements agree very well with the earlier measurements on *Loligo* rhodopsin, and their analysis by Hubbard and St. George[2]. It is of some interest that these three cephalopods represent two sub-orders and three families: the Decapoda, which include the squid and cuttlefish in separate families, and the Octopoda.

The rhodopsins of these cephalopods demonstrate a condition that has already become familiar in vertebrate rhodopsins: a considerable spread of absorption spectra, $\lambda_{\max.}$ ranging from 475 to 493 mμ. In these animals as in the vertebrates this variation results from the fact that though all known rhodopsins have the same chromophore, neo-b retinene, each species of animal possesses a different opsin; and with this go differences in the absorption spectrum and other properties.

In all three cephalopods, the actio
rhodopsin yields a relatively stable n
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This investigation was supported in p
to Prof. George Wald from the U.S. C
Research. We should like to tha
Dohrn, director of the Naples Zoolo
and members of the staff for the facili
our disposal there and for their ma
during our stay.

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A TEMPLATE MODEL FOR THE SYNTHESIS OF RIBONUC ACID FROM DEOXYRIBONUCLEIC ACID

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THE suggestion has been made that the nucleotide composition of nuclear ribonucleic acid could be accounted for by assuming that the nuclear ribonucleic acid is synthesized on a double helical deoxyribonucleic acid template with each base pair providing a specific site for a nucleotide of ribonucleic acid[1]. The two alternative possibilities to which one is led by these chemical data are listed in Table 1, where *A–T* 1 refers to the deoxyribonucleic acid base pair with adenine on chain 1 of the double helix and thymine on chain 2, and *A–T* 2 to the reverse situation. If this scheme is correct, it might be possible to determine the actual sites on the template by examination of molecular models, and it is the purpose here to discuss the results of a systematic investigation of molecular models.

Initially, let us consider some of the general requirements of a template which we define as a system capable of producing a polymer with a specific linear sequence of monomers. We shall take the
problem of deoxyribonucleic acid syr
illustration of a template because t
evidence that a single chain of this ac
plate for the production of a complem
That is, it appears that the polynucleot
a single chain of deoxyribonucleic a
specific sites for the construction of a co
chain with adenine functioning as a sp
thymine, guanine for cytosine, thymin
and cytosine for guanine. The specific
determined by favourable hydrogen-bon
between these base pairs, but obvious
this is involved. Otherwise, we would ex
for example, to be a site for guanin
thymine, since it is possible for adenin
same pair of hydrogen-bonds with th

Table 1

Deoxyribonucleic acid base pair (*a*)		(*b*)	Ribonuc base de
A–T 1	or	*A–T* 2	guan
A–T 2	or	*A–T* 1	cyto
G–C 1		*G–C* 1	urac
G–C 2		*G–C* 2	aden

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* Postdoctoral Research Fellow of the U.S. National Science Foundation.

nucleotides. We have concluded that the success of the deoxyribonucleic acid template is at least partly due to the fact that the hydrogen-bonded base pairs, adenine and thymine, guanine and cytosine, are identical in so far as they may be fitted into a completely regular double helix structure. If we visualize the process of polymerization involving the template the advantages of this structural regularity becomes clear. Consider a single chain of deoxyribonucleic acid acting as a template and a second growing chain partly formed on it; then, where a second chain is formed, the resulting double chain polynucleotide would probably coil up into a helical structure identical with deoxyribonucleic acid because this would be the energetically favourable situation. If we now add a monomer to the growing chain, and adenine is the first unpaired base on the template, either guanine or thymine could form the same pair of hydrogen-bonds with it. However, due to the deoxyribonucleic acid-like configuration of the polynucleotide chain to which we expect the monomer to add, only thymine can hydrogen-bond favourably with adenine and still have its reactive sugar phosphate group in a position where addition to the growing chain is possible (regardless of the intermediate chemical steps involved). Thus, only thymine is capable of becoming a permanent component in the growing polynucleotide chain when the opposing base on the template is adenine. A similar argument would apply to the other bases. In summary, we see that the specificity of the deoxyribonucleic acid template site (apart from enzymes involved) involves at least two conditions: (1) energetically favourable binding of its monomer nucleotide counterpart; (2) binding in such a way that the reactive group of the bound monomer is in a position to condense on the growing end of the polymer chain.

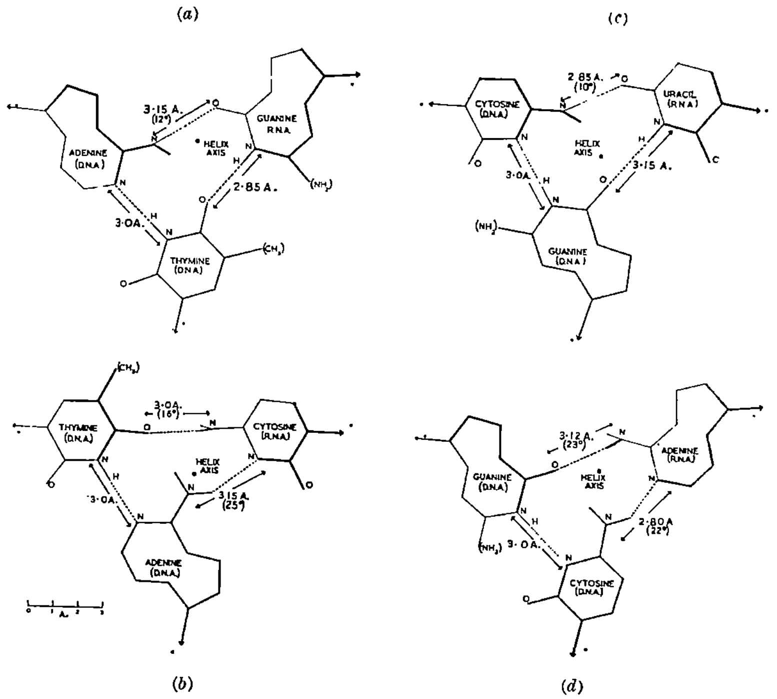

Fig. 1. Nucleotide triplets which may be involved in the template

I have attempted to find specific sites for the binding of the four commonly occurring ribonucleotides to the deoxyribonucleic acid base pairs which would satisfy requirements similar to the two just discussed. Initially, I sought specific sites for binding ribonucleotides to the deoxyribonucleic acid in its normal double helical configuration. However, it was not possible to satisfy conditions (1) and (2) simultaneously and, therefore, I have concluded that deoxyribonucleic acid is not capable of acting as a template for ribonucleic acid synthesis without undergoing major configurational changes. Indeed, only one type of modification in the deoxyribonucleic acid molecule has led to a molecular model in which we could approximately satisfy our two conditions. This modification involves three steps: the breakage of hydrogen-bonds between the amino-group and the carbonyl group in both base pairs of the deoxyribonucleic acid; the twisting of the planes of the bases relative to one another; and, in some cases, a rotation of the adenine and cytosine amino-groups out of the plane of the base. (A similar change has been described in more detail for the synthetic complex, polyadenylic acid/2 polyuridylic acid[3].) Together with these alterations in the bases, adjustments in the configuration of the sugar phosphate backbone becomes necessary; nevertheless, I shall leave these unspecified at present. The systematic breakage of the amino-carbonyl hydrogen-bonds leaves the two deoxyribonucleic acid chains still connected by NH . . . N hydrogen bonds. If we now consider the binding of ribonucleic acid base groups by this system, there are in all eight nucleotide triplets we must inspect. First, we have attempted to build identical hydrogen-bonded triplets (identical being used in the same sense as before) using the four triplets that would occur in the code suggested from the chemical data in Table 1. In Fig. 1 we see the outcome of this attempt. The base triplets are shown in two-dimensional projection. The bases are represented by light, medium and heavy lines to illustrate that they are respectively, below, in or above the plane of the paper. In all cases, the deoxyribonucleic acid base on chain 1 is drawn in the plane of the paper, and the other two bases are tilted from the plane of the paper by about 18°. The helix axis is perpendicular to the plane of the paper; its indicated position is only approximate. (I have arbitrarily chosen the tilting arrangement in the figures since it would be possible to tilt in the reverse fashion, by taking the mirror image in the plane of the paper. Probably when the problem of wrapping the triplets into a helical structure is considered in more detail, regular tilting of one sort would be favoured.) The arrows attached to the nucleotides represent the connecting link to the C_1 atoms of the sugar. The dots near these arrows represent the average positions of the C_1 atoms for the four triplets and it can be seen that the maximum deviation from this average is 0·5 A. The hydrogen-bond distances, N—H . . . X, are indicated in the figures, and the deviation of the N—H . . . X angles from linearity is indicated in

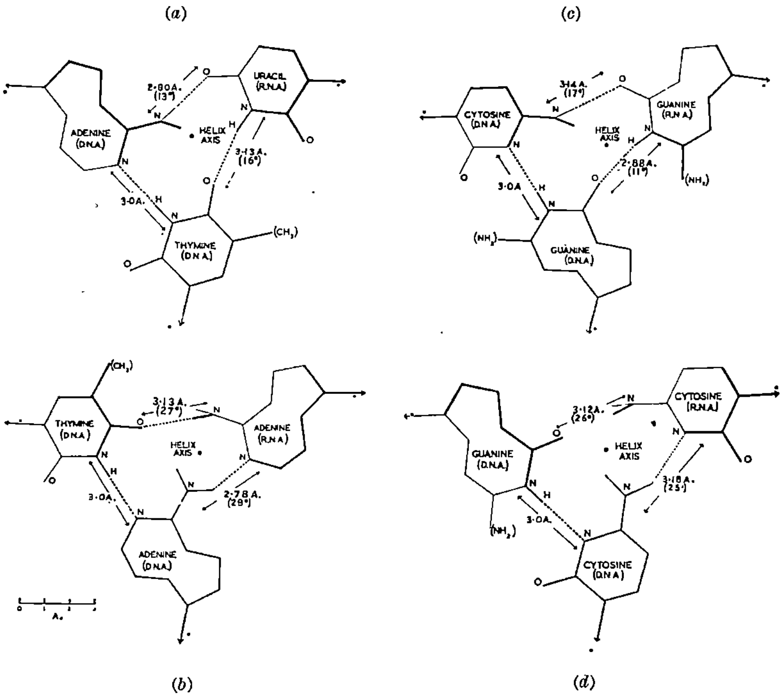

Fig. 2. Nucleotide triplets which might interfere with the template

parenthesis below the hydrogen-bond distances. I have used the limits suggested by Donohue[4] for the hydrogen-bond lengths and I have restricted the deviation of the N—H . . . X angle from linearity to 28°. Within these limits it has not been possible to make the four triplets identical. Nevertheless, it seems likely that it would be possible to construct a fairly regular three-stranded helical model with reasonable van der Waals contacts using the triplets in Fig. 1 more or less interchangeably. Thus, the template model suggested by Fig. 1 is structurally reasonable and consistent with the chemical data in Table 1. Consequently, a three-stranded helical molecule involving the triplets in Fig. 1 could be an intermediate complex in the synthesis of nuclear ribonucleic acid.

Despite this limit
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because of the large number of pos
of nucleotide triplets, and an investi
possibilities will be postponed until
data have been obtained.

I would like to thank my coll
Laboratory for the use of molecular
their advice and criticism.

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CONTROL OF LECITHINASE ACTIVITY BY THE ELECTROP CHARGE ON ITS SUBSTRATE SURFACE

By A. D. BANGHAM and R. M. C. DAWSON

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It has been shown that a preparation of the phospholipase (lecithinase) from *Penicillium notatum* which normally only hydrolyses lyso-phospholipids will also attack lecithin providing this substrate contains small amounts of an activating lipid, such as monophosphoinositide or polyglycerolphospholipid[1]. The addition of these activating lipids to lecithin caused a marked reduction in the extent to which the lecithin was extracted from aqueous emulsions by lipid solvents such as ether, a property which ran closely parallel to the developme
activity[2]. This suggested that the
connected with some change in th
lecithin particles. It was, theref
examine the particles by microelectro
determine the sign and magnitude
phoretic charge.

Ovolecithin was isolated by chr
alumina and silicic acid columns a
viously[2], and emulsions were exami

electrophoresis cell of the type developed by Bangham, Flemans, Heard and Seaman[3]. The lecithin particles were found to have a net zero charge from pH 3·0 to 13·0 when emulsified in 0·145 M sodium chloride. In formate buffer at pH 3·3 which was optimal for enzyme activity, the particles had a small positive charge. On the addition to the lecithin of a small percentage of certain lipids which had previously been found to activate its enzymic hydrolysis (monophosphoinositide and cardiolipin), the lecithin particles acquired a net negative charge. It seemed likely that the reason for this was that these activating lipids possess a negative polar group in the tertiary dissociable hydrogen atom of the phosphate moiety which is not compensated for by a positively charged basic group. It was consequently expected that any molecules possessing a hydrophobic portion and a negatively charged polar group (amphipathic) would also render a lecithin surface susceptible to enzymic attack. It was shown that dicetylphosphoric acid, taurocholic acid and dodecyl sulphate also activated the enzyme system and produced a net negative charge on the lecithin surface at pH 3·3. The latter compound, however, would only activate the lecithinase within a comparatively narrow range of concentration.

With the activators so far studied, it was necessary to add a certain critical concentration to the lecithin before enzyme activity began. As the concentration of activator was further increased, the lecithinase activity rapidly reached a maximum, and with the further addition of activator there was a decrease in the amount of lecithin hydrolysed by the enzyme. At the concentration at which activation commenced, the lecithin had acquired a net negative electrophoretic charge which was approximately the same when either dicetylphosphoric acid or cardiolipin was used as the activator. This suggests that a certain critical negative charge density on the lecithin surface may be necessary for the commencement of the enzymic attack.

Evidence substantiating the theory that a negatively charged lecithin surface is necessary for enzyme action was obtained by studying its inhibition by metal ions such as UO_2^{2+}, Th^{4+}, and Ca^{2+}, which are efficient counter ion-binders of the negative groupings on a lipid surface[4]. Using a lecithin surface activated with dicetylphosphoric acid, it was shown that at the exact concentration of these ions necessary to neutralize the charge on the lecithin surface, the inhibition of enzymic activity became complete. In further experiments, positive amphipathic molecules were introduced into a negative surface of lecithin plus dicetylphosphoric acid particles by the gradual addition of cetyltrimethylammonium bromide, and here again there was a similar 'cut off' of enzymic activity just before the point at which the surface changed from being negatively charged to positive.

The question remained as to whether the negative charge on the surface of the substrate activated the actual attack of the enzyme on the lecithin surface or whether it merely solubilized the substrate by a detergent-like action, the subsequent enzymic attack occurring in the bulk phase. Microscopic examination of lecithin emulsions and high-speed centrifugation suggested that some dissociation of the lecithin particles into smaller micelles did occur with increasing concentrations of activator. However, there appeared to be no connexion between this more efficient emulsification and the development of the enzymic attack. Proof that the negative groupings were directly concerned with the actual enzymic attack on a lecithin surface was obtained by using surface films of yeast lecithin of high specific activity labelled with phosphorus-32. These films were introduced on the surface of a formate buffer at pH 3·3 and the counts per minute coming from the surface recorded with a mica end-window β-counter. The buffer was stirred magnetically from the underside so that any water-soluble glycerylphosphorylcholine produced by enzymic activity would be distributed throughout the bulk phase and its phosphorus-32-counts not recorded. With pure lecithin films injection of the enzyme into the bulk phase produced no change in the counting rate. When films were prepared from lecithin labelled with phosphorus-32 mixed with a small percentage of activator (for example, dicetylphosphoric acid, cardiolipin), there began a steady loss of radioactivity from the surface within a few minutes of the introduction of enzyme into the formate buffer. This loss was largely prevented by the addition of 0·02 M sodium fluoride to the bulk phase, a concentration which is sufficient to inhibit the enzyme almost completely. The loss of radioactivity was also not observed when the pH of the buffer was changed to 4·4, which is away from the optimum for enzyme activity. These experiments indicate that the enzyme acts directly on the activated surface of the lecithin film since any reaction occurring in the bulk phase would not be recorded by a change in the counting rate.

So far as we are aware, this is the first time that the activity of an enzyme has been directly related to the electrical (electrophoretic) charge on its substrate surface. The mechanism by which the lecithin surface becomes active when a critical density of negative polar groups is reached is not clear. Electrophoresis measurements on paper show that the enzyme is isoelectric at pH 3·3 so that the activation effect of the negative groups would appear to depend on orientation of the enzyme molecule within the diffuse ('double') layer rather than on simple electrostatic attraction and adsorption. This conclusion is supported by an observation that in the presence of the enzyme the lecithin surface remains negative, whereas, as is generally known, the non-specific adsorption of a protein at its isoelectric point on a negative surface leads to a masking of the charge.

In the inhibition experiments with metallic ions, it was observed that at concentrations of Th^{4+} or UO_2^{2+}, which were just insufficient to inhibit the enzymic activity, there was a distinct stimulation of the lecithinase action. This suggests the possibility that the metallic ions may initially mask negative groupings on the enzyme molecule itself, which would further assist the enzyme to orientate itself in relation to a negatively charged lecithin surface. If this is so, it would help to explain why the 'cut off' of enzymic activity with increasing amounts of these metal ions occurred when the lecithin surface was electrically neutral rather than at the critical negative charge density necessary for the development of enzymic attack. It is proposed to publish a fuller account of this work at a later date.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Fall-out Radioactivity in a Deer's Antlers

The accumulation of radioactive material in biological structures as a result of fall-out from nuclear explosions presents a continuing and increasing problem in relation to human food supplies. It is now well established[1,2] that radiostrontium-levels in the bones of children are higher than in adults, and this is clearly related to the rate of deposition of 'new' calcium in the skeleton. The rapidity with which the antlers of deer are formed, coupled with the fact that these animals normally graze on upland pastures which are known to contain relatively high levels of fall-out radioactivity[1], suggested that antlers might well show particularly heavy contamination with radiostrontium. An opportunity was therefore taken during the course of a survey of radiostrontium-levels in foodstuffs to include for assay a pair of antlers from a deer shot on the island of Islay on November 3, 1957.

One complete antler was ashed, a strontium separation carried out with added carrier and the activity measured on a Geiger–Müller counter. The activity (strontium-89 plus strontium-90, and possibly active traces of other alkaline earths and heavy metals) was found to be 126 $\mu\mu$c./gm. of calcium present. At about the same time, a transverse section 2 mm. thick was cut from the other antler of the pair at one of the points of branching and applied in close contact with a piece of 'Kodirex' X-ray film. This was then exposed for 82 days in a light-tight box and the resulting autoradiogram is shown in Fig. 1.

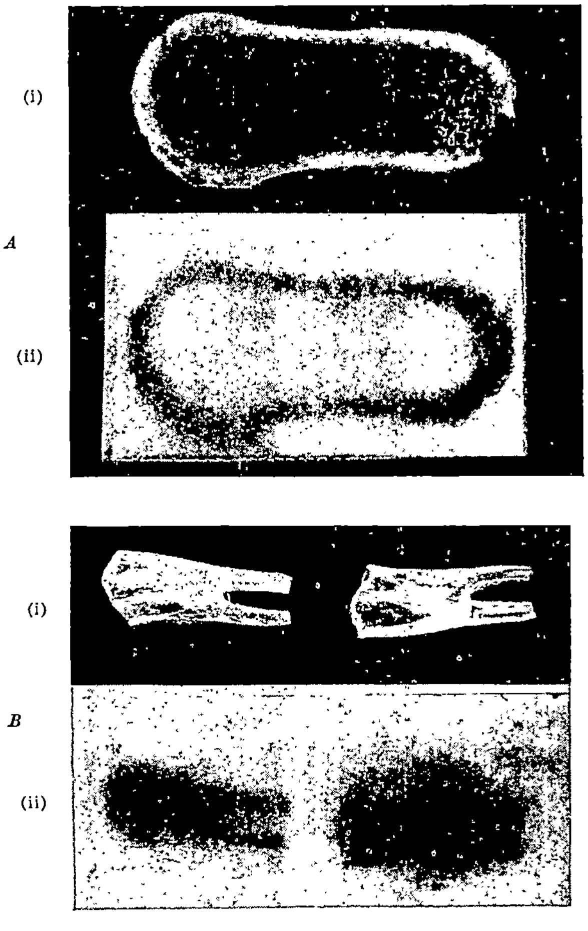

Fig. 1. *A*, Cross-section of deer's antler (i) and autoradiogram produced from it (ii). *B*, Two halves of a sheep's premolar from Ben Lawers, Perthshire (i) and the corresponding autoradiogram (ii)

A check on the distribution of activities between the two obvious concentric zones of the section was made by separating these two regions from a 2-in. length of the same antler and recovering the strontium from each. The results showed an activity in the dense peripheral zone of about nine times that in the central zone of spongy material, per unit area of cross-section.

We were later able to obtain a pair of antlers from a deer shot in the same area in 1952 for use in a control experiment. The strontium activity of this sample obtained by the same method as before was 11·2 $\mu\mu$c./gm. of calcium. Exposure of a similar section from these antlers to X-ray film for a period of 92 days produced a very slight image which was insufficient to allow photographic reproduction. It is therefore concluded that the major part of the blackening on the original autoradiogram is due to the longer-lived fall-out elements, in particular to the strontium isotopes.

We have since obtained autoradiograms of other biological structures, including a premolar of a sheep found dead at about 1,700 ft. on the side of Ben Lawers, Perthshire (see also Fig. 1) and of grass from the same area, which is known (unpublished work by Hawthorn, J., Stanwix, P. R., and Duckworth, R. B.) to contain high levels of radioactive strontium. We are not aware of the previous publication of autoradiograms of biological structures due purely to general fall-out radioactivity.

Our thanks are due to Dr. McGowan of Callumkill, Island of Islay, for supplying the antlers.

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Accumulation of Strontium-90 in Dental Tissues

Weanling rabbits given single injections of 500–1,000 μc. strontium-90 per kgm. showed a high frequency of tumours of the jaw[1], and preliminary histological studies suggest that they arose in close relation to the teeth. The amount of strontium-90 accumulated in individual teeth and in all teeth of one upper quadrant of the jaw after a single intravenous injection of 100 μc. strontium-90 per kgm. is given in Table 1. The amount of strontium-90 in the teeth is seen to increase with time after injection for at least thirty days and then to fall abruptly. The teeth of the rabbit grow continuously, and strontium-90 is lost because the layers in which the strontium is initially deposited erupt into occlusion and are later worn away in mastication. A similar

Table 1. STRONTIUM-90 IN TEETH AND FEMUR

No. of rabbit	Time interval between injection of strontium-90 and death	Individual teeth (mμc. per tooth) Incisors	Premolar 1st	Premolar 2nd	Molar 1st	Molar 2nd	Molar 3rd	Teeth (combined) from one jaw quadrant (μc.)	Femur (μc.)
993	8 hr.	82	42	40	120	90	81	0·45	4·6
996	24 hr.	63	61	71	99	100	52	0·45	4·1
999	3 days	110	51	71	130	73	68	0·50	3·0
997	9 days	120	86	120	120	120	99	0·67	2·2
998	30 days	110	74	130	150	130	100	0·70	1·8
1,000	90 days	33	12	33	43	32	27	0·18	—
970	180 days	3·0	1·9	2·4	2·3	3·2	1·8	0·015	0·91
992	180 days	7·7	2·2	4·3	5·1	4·7	3·6	0·028	0·87

sudden loss of strontium-90 from the teeth of the rat may be seen autoradiographically[2].

The initial increase with time after injection in the amount of strontium-90 in the teeth is in marked contrast to the steadily decreasing amount of strontium-90 in the femur (Table 1). This difference in behaviour between tooth and bone may be due to the substantial remodelling which occurs in bone but not at all in teeth, or because ion exchange in the mineral of bone is much greater than in the mineral of the teeth. In either case the liberation of strontium-90 from bone into the blood stream, during the days and weeks after a single intravenous administration, provides a continuously available source of strontium-90 for incorporation into the actively calcifying teeth, so that their strontium-90 content continues to increase with time until the moment when the first deposit reaches the masticatory surface and begins to be worn away. Thus the intensity with which the jaw is irradiated by a local radioactive deposit in the teeth may well be quite unrelated to general levels of deposition in bone.

This may be specially important in species like man, where the teeth do not wear away to the same extent as, and where strontium-90 incorporated into calcifying teeth will be much more permanently fixed than, in rodents.

One of us (W. H.) is indebted to the Royal Naval Physiological Laboratory, Alverstoke, for laboratory facilities and technical assistance. The help of Mr. R. H. Watts, of the Medical Research Council staff, is gratefully acknowledged.

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Shifts of Arc Lines at Various Pressures in Magnetic Fields

AN investigation of certain spectral lines emitted in a high-voltage arc between brass electrodes in nitrogen gas was made under pressures of from 1/7 to 85 atmospheres. The arc was run in and out of a magnetic field of 4,000 gauss. An empirical relation between the shift with and without a magnetic field at varied pressures for nine spectral lines has been found. There was a certain amount of scatter in the shifts of the lines, but among the hundreds of measurements of the spectral lines studied from Eastman Kodak spectrum analysis No. 2 plates, a significant pattern of shifts was found which differed for emission in a magnetic field from emission in a non-magnetic field.

Although the shift of any particular arc line under pressure is not steady the emergent pattern is quite evident. In all cases, the shift due to pressure in a magnetic field is less than in a non-magnetic field. With the exception of the first principal lines of copper, the shift of which seems to be anomalously changed by the magnetic field, lines most shifted by the pressure are most affected by the magnetic field.

In Fig. 1 pressure shifts of spectral emission lines of zinc, copper and lead in a magnetic and non-magnetic field are shown. It is apparent that, in addition to a decreased pressure shift in a magnetic field, the slopes of the lines for pressure shift versus pressure are less steep for emission in a magnetic than in a non-magnetic field. The ^3P–$^3P'$ lines of lead are an exception. Even for lead, the slope is not greater in a magnetic field. Lead lines were the only ones considered for which the coupling was *j*–*j*.

These results give considerable support to the theory that the normal van der Waals forces responsible for pressure shift are counteracted in a magnetic field by

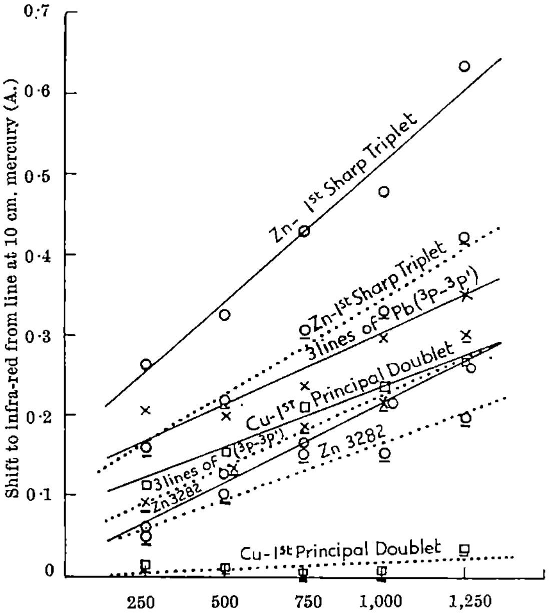

Fig. 1. Pressure shifts of arc lines: – – –, in the presence; —— in the absence of a magnetic field. Curves are straight lines of best fit, through averaged points determined for zinc, ○; lead, ×; and copper, □. Underlined symbols refer to measurements in a magnetic field

space-charge forces. In a magnetic field, electrons and ionized metal gas ejected from the electrodes follow different paths between the high-voltage (5,000-V. a.c.) electrodes. It is suggested that a space charge made up of ions of vaporized metal is present in the space of the discharge when a magnetic field is applied. The magnetic field is perpendicular to the electric field between the electrodes. Motion of the charged particles is reversed by the a.c. electric field 120 times per second. In their much slower acceleration from zero velocity, the positive ions are diffused more than electrons by the force of the magnetic field transverse to their direction of motion.

The effect of the positive space charge is to increase the energy of electron transitions responsible for the spectral lines. The negative electronic charge belonging to an atom about to emit radiation is drawn farther from the nucleus by the surrounding positive-ion plasma. Pressure-shifted emission lines with a magnetic field will be to the violet side of pressure-shifted emission lines without a magnetic field.

This work was done at Fordham University, New York City, in 1955.

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Space-Charge Limited Currents in Insulating Materials

The modern theory of solids predicts that an electron can travel freely through the periodic potential field of a perfect crystal lattice provided that its energy lies within certain well-defined limits, or energy bands, which are characteristic of the crystal. A practical implication of this is that, if a sufficient number of such 'free' electrons can be introduced from a metal cathode into the allowed bands of an insulating crystal, it should be possible to obtain a space-charge limited current flowing through the crystal. Such a current flow would be analogous to the space-charge limited current which flows across the evacuated region between the cathode and anode in a thermionic vacuum diode.

Previously, two circumstances in the main have prevented the observation and subsequent exploitation of space-charge limited currents in insulating crystals. First, the presence of surface potential steps, due mainly to differences in magnitude between the work function of the metal cathode and the electron affinity of the crystal, have prevented the bulk introduction of electrons from the metal into the allowed bands of the crystal. Secondly, even the best crystals it is possible to grow contain lattice defects which act as trapping states and trap any initial electron flow to produce a fixed space-charge field which builds up to oppose further current flow.

Although the exploitation of space-charge limited currents in insulating materials has not yet been achieved, several theoretical studies of the anticipated characteristics of such currents have been reported. In particular, by neglecting the influence of thermal diffusion of electrons, trapping states, residual small concentrations of donor centres, and the influence of the anode electrode, Mott and Gurney[1] have shown that the space-charge limited current density should be given by $J = 9\varepsilon\nu V^2/8d^3$ amp./m.², where ε is the absolute permittivity and d is the thickness of the insulator, and ν is the mobility of the electrons in the insulator. At sufficiently high applied voltages the whole of the space-charge in the insulator should be drawn across. The current should then become proportional to voltage, since the drift velocity of the electrons would be proportional to the applied field. Under these conditions the current density should be given by $J = e\nu N_0 V/d$ amp./m.², where N_0 is the space-charge electron density in the insulator at the surface in contact with the cathode, and the approximate transition voltage between space-charge limited and proportional currents should be given by $V_S = 8ed^2N_0/9\varepsilon$ volts. These calculations have been extended by Lampert[2] to include the effects of deep trapping states. His equations show that as the applied voltage is increased the current flow should initially be very small, but should rise extremely rapidly at a certain critical voltage to reach the space-charge limited value at an applied voltage given approximately by $V_t = ed^2N_t/2\varepsilon$ volts, where N_t is the density of trapping states. A further case of interest has been studied by Skinner[3], who has considered the flow of current in an ideal insulator bounded by two metal electrodes of different work functions. These calculations indicate, as expected, that current rectification should be obtained.

These anticipated properties of space-charge limited currents in insulating materials suggest the exploitation of these currents to develop a new class of solid state devices[4]. Experiments to this end have been made in my laboratories during the past two years and the expected characteristics of these currents have been demonstrated in crystals of cadmium sulphide.

Fig. 1 shows the steady current – voltage characteristic of a thin crystal plate about 3 × 10^{-3} cm. thick. The crystal was provided with a cathode of indium metal about 1 mm.² in area, vacuum-welded to one surface, and an anode, in the form of a coating of colloidal graphite, on the other surface. The curve

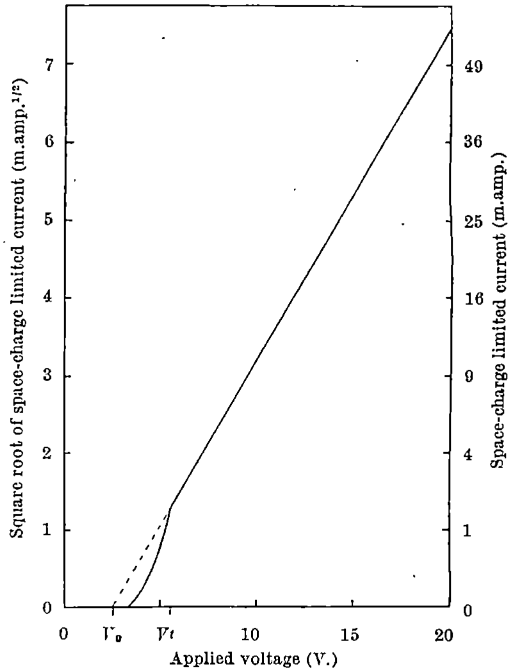

Fig. 1. Current – voltage characteristic of space-charge limited current in a cadmium sulphide crystal. The curve shows the relation between the square root of the current and the applied voltage

shows the forward current characteristic for this crystal measured at room temperature (20° C.) and is typical of the results obtained so far. Photoconductive effects were eliminated by enclosing the crystal in a light-tight container. As the applied voltage was raised no current-flow could be detected ($i < 0{\cdot}05$ μamp.) until a voltage $V_0 = 2{\cdot}5$ volts was reached. The presence of this threshold voltage is attributed basically to the difference in magnitude between the electron affinity of the crystal and the work function of the anode; this difference must be overcome by the applied voltage before appreciable current can flow. As the applied voltage was increased further a very small current commenced which then rose rapidly to about 2 m.amp. at a voltage $V_t = 5{\cdot}7$ volts. In this region considerable time was required for the current flow to reach a steady value and the current – voltage curve was quite steep up to the space-charge limited value. These characteristics are attributed to the influence of deep trapping states. This measured value of V_t indicates that the density of deep trapping states in this crystal was of the order of 10^{13} per cm.^{3}, which is satisfyingly low. For higher voltages the current flow was quite steady and reproducible provided that thermal effects due to power dissipation were avoided. In this region the precise square-law characteristic expected for space-charge limited currents was obtained. From the slope of this part of the curve the mobility of the electrons in the crystal was found to be approximately 500 cm.^{2}/V. sec. This is a rather high figure for cadmium sulphide, but is probably explained by the relative freedom of this particular crystal from lattice defects and trapping states.

In order to supply the magnitudes of space-charge limited currents observed, the electron space-charge density N_0 in the crystal at the surface in contact with the cathode must have been of the order of 10^{19}/cm.^{3}. This implies that the conduction band of the crystal at the cathode was within 0·05 eV. of the Fermi-level of the cathode metal.

In the reverse direction the crystal was, as expected, an insulator. At applied voltages up to 20 V. the current flow was undetectable with a sensitive galvanometer, indicating a reverse resistance greater than 10^{11} ohms. At 80 V. the reverse resistance was still of the order of 10^{10} ohms.

These various properties of current flow in insulators make this a worthwhile field for fundamental studies and for the design and development of new solid state devices. For example, much information can be obtained about lattice defects in dielectric crystals by studying electron trapping and scattering; the electron affinities of dielectric crystals can be measured directly, giving useful information to assist theoretical studies of crystal and surface structures; and the nature of contacts between conductors and insulators can be examined directly. From the point of view of the developing devices the exploitation of space-charge limited currents in insulating materials is attractive for many reasons apart from the promise of many new types of devices. For example, by working under space-charge limited conditions, relative insensitivity to changes in temperature should be achieved; this is an appreciable advantage for a solid state device.

As yet only preliminary experiments and measurements have been made and it is certain that many problems have to be solved before successful and reliable devices can be designed. Even so it seems clear that the study of space-charge limited current flow in insulating materials will be a fruitful field for fundamental investigations and will lead to the development of many new types of solid state devices.

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Effects of Electron Bombardment upon Sodium Tetraborate and Boric Acid in an Electron Microscope

THE specimens under observation in the electron microscope are exposed simultaneously to a high vacuum and to electron bombardment. Under these conditions, the specimens may lose volatile constituents due to the combined effects of the vacuum and of the temperature rise[1,2]; also the crystal structure may undergo alterations as a result of exposure to the electron beam[3].

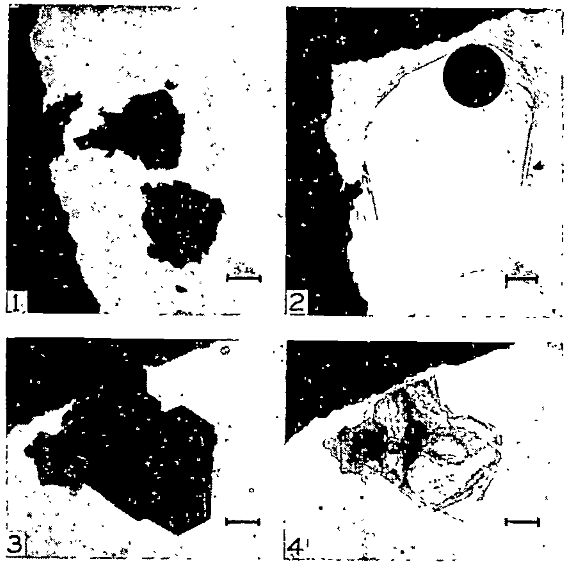
A systematic study was conducted on the effect of electron bombardment upon crystals in an electron microscope, especially on acetates, carbonates, oxalates and some crystalline organic acids (Souza Santos, H. L., unpublished work). This study was intended to correlate the morphological changes in the crystal which are observable with the electron microscope and the physical and chemical transformations with the temperature rise which can be expected from the chemical composition of these substances.

In the course of these studies, some observations on the behaviour of sodium tetraborate and boric acid were made which are of interest in view of the similarity of the effects of temperature of these substances[4].

Sodium tetraborate dissolves in its own water of crystallization at 75° C. at atmospheric pressure; it loses five molecules of water at 100° C. and nine at 150° C., becoming anhydrous and melting at 320° C. On further heating, it swells up to a spongy mass; at a higher temperature, this mass runs together, forming a clear colourless glass—borax glass—the melting point of which is reported[5] to be between 561° and 878° C.

Boric acid, when heated to 70° C., loses no water; at 100° C., it loses two-thirds of its water and at 160° C. it melts, forming dihydrotetraboric acid ($H_2B_4O_7$). At a higher temperature, the acid froths up, losing its water and forming a fused viscid mass of anhydride, which on cooling congeals to a transparent but fissured glass. At a red heat, boric acid loses all its water with much bubbling[4].

From their physico-chemical properties, it could be predicted that sodium tetraborate and boric acid would give similar effects under electron bombardment, namely, melting of the crystals, formation of spherical drops or reunion of many drops into a single one, loss of water as vapour accompanied by bubbling, residues of borate glass and boric anhydride.



Figs. 1 and 2. Sodium tetraborate crystals before and after bombardment

Figs. 3 and 4. Boric acid crystals before and after bombardment Scale: 5μ

The following method was used for preparing the specimen. Dry powdered samples of analytical grade boric acid (H_3BO_3) and sodium tetraborate ($Na_2B_4O_7.10H_2O$), were deposited on nickel grids covered with 'Parlodion'; the excess solid was removed by turning the grids upside down, thus leaving some minute crystals adhering to the plastic. An *RCA* type *EMU* electron microscope operating at 50 kV. with self-biased gun was used. The lowest possible current intensity was used at first, and this was raised until the morphological changes appeared. Wherever possible, electron micrographs were taken at the initial, intermediate and final stages of bombardment.

Under electron bombardment the particles of sodium tetraborate seem to melt, giving spherical drops; when many particles are in contact the drops aglomerate into a single drop, as do liquid drops, due to surface tension. Fig. 1 shows sodium tetraborate particles taken with a low-intensity electron beam. Fig. 2 shows the same particles after strong bombardment; the particles are united into one almost spherical particle.

In the electron microscope electronically dense particles of boric acid lose their opacity to electrons, leaving transparent envelopes, which retain the original shape of the particles. Fig. 3 shows some boric acid crystals in an early stage of bombardment; a region is becoming transparent; before bombardment the whole crystal was quite opaque. In Fig. 4 the same crystal shows only the residual transparent envelope after strong bombardment.

The predictions were confirmed in the case of sodium tetraborate, but not for boric acid, the behaviour of which is that of a completely volatile material; this contradiction could be explained by the fact that boric acid is relatively volatile in steam[1, 6]; its vapour pressure is 242 mm. of mercury at 128° C., this temperature being in the range of calculated values for specimens in an electron microscope[7].

Further studies are in course and will be published elsewhere.

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Origin of Tektites

In the recent controversy concerning the origin of tektites[1,2], Kopal has given reasons for considering that they must be formed close to the terrestrial surface, and regards these as grounds for favouring Urey's cometary theory[3]. It appears useful to direct attention to another suggestion which may have been overlooked—the 'plastic sweeping' theory of Hardcastle[4].

Briefly, Hardcastle suggests that tektites have been formed from stony meteorites by the process of ablation during their passage through the atmosphere. The glazed surface of these meteorites is considered to contain an enriched content of silica, and to be swept away piecemeal during flight. The solidified remnants land as tektites. The considerable ablation known to take place, and the comparatively long-lived trails observed in stony meteorite falls are adduced to support the theory. Attention is also directed to the marked pitting of the stones and the size of the pits.

An analysis of the glazed surface material would enable a test of this suggestion to be made. It might be expected to contain a selective sample of the material of the meteorite rather than to reflect the average composition. In view of Urey's statement that "the chemistry of silicate material is not completely known", such an analysis would provide additional relevant data.

The 'plastic sweeping' theory appears to explain: (1) the derivation of tektite material from meteorites of known composition; (2) a rapid heating process capable of producing the observed physical forms; (3) an explanation of the wide scattering. The most serious objection appears to be the limited time-scale within which tektite falls are known to have taken place. Urey, on the other hand, appears to consider two comets only, one in Eocene time, which produced the bediasites, and the other in the Pleistocene, producing the other falls. Even granting the possibility of fragmentation of the cometary nucleus, it seems doubtful whether the observed distribution is satisfactorily explained. In these respects, the lunar impactite theory is superior.

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Determination of Hammett Sigma Constants by Intramolecular Hydrogen Bonding

THE extensive literature that exists concerning Hammett's σ-constants has been subjected to several recent reviews, including a compilation and examination of available data[1], a discussion of the significance and limitations of the concepts involved[2], and an attempt to deduce best values and probable errors for the σ-values[3]. In most cases σ-values have been determined by examination of equilibrium constants or reaction-rate constants of substituted benzene derivatives, thus requiring consideration of product states or transition states. In the few instances where examination of the native (unreacted) molecule has led to a determination of σ (via physical measurements), the site examined has invariably been attached directly to the ring carrying the groups under study, thereby still exerting some influence (other than electronic) on the effect measured as well as excluding the *ortho*-position for steric reasons.

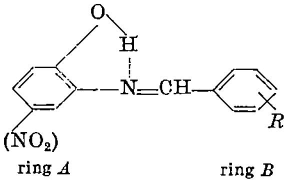
Table 1

Substituent (ring *B*)	σ-*ortho*	σ-*meta*	σ-*para*
F	+ 0·17 (*a*)	+ 0·31 (*a*) + 0·337	+ 0·15 (*a*) + 0·062
Cl	+ 0·22 (*a*)	+ 0·38 (*a*) + 0·373	+ 0·20 (*a*) + 0·17 (*b*) + 0·227
Br			+ 0·25 (*a*) + 0·24 (*b*) + 0·232
CH_3	− 0·14 (*a*)	− 0·07 (*a*) − 0·069	− 0·14 (*a*) − 0·170
NO_2		+ 0·75 (*a*) + 0·710	+ 0·778
OH	*	+ 0·05 (*a*) + 0·121	− 0·32 (*a*) − 0·37
OCH_3	− 0·34 (*a*)	+ 0·04 (*a*) + 0·11	− 0·28 (*a*) − 0·27 (*b*) − 0·268
$N(CH_3)_2$			− 0·80 (*a*) − 0·91 (*b*) − 0·83

Values (*a*) obtained with ring *A* unsubstituted, with carbon tetrachloride as solvent ($K = 0·033$). Values (*b*) obtained with a 4-NO_2-group in ring *A*, with methylchloride as solvent ($K = 0·033$). Unmarked values are from ref. 3 for comparison.

* Unobtainable due to the preferred hydrogen bonding from the ring *B* phenolic hydroxy group.

A method has been devised which permits estimation of the Hammett σ-constant in a manner circumventing many of these objections. In the system:



the group being investigated (*R*) is physically isolated from the O—H · · · N hydrogen bond regardless of its position on ring *B*. Its effect on the basicity of the nitrogen may be measured, none the less, by the strength of the hydrogen bond on the phenol group of ring *A* as determined by the exact frequency of the O—H stretching vibration. Table 1 shows various σ-constants obtained from the expression:

$$\sigma = \Delta\nu_{OH} \cdot K$$

where $\Delta\nu_{OH}$ is the frequency shift of the substituted homologue (in wave-numbers) compared with the unsubstituted parent compound, and *K* is a factor employed to bring these wave-number shifts into the range of the classic Hammett σ-values.

The figures above show that when steric effects are eliminated, the *ortho* and *para* σ-constants are nearly the same. A more elaborate discussion of the principles involved, and a description of experimental detail, will be published elsewhere.

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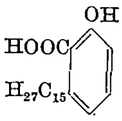
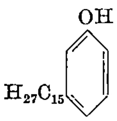
Surface-active Characteristics of Sodium Anacardate isolated from Cashew Nut Shell Oil

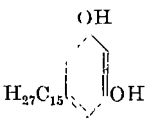
CASHEW nut (*Anacardium occidentale* Linn.) shell liquid obtained from unroasted shells was found by Stadeler[1] to consist chiefly of anacardic acid (*A*) (on heating, this is decarboxylated to cardanol (*B*)), a salicylic acid derivative with a long unsaturated side-chain in the position *ortho* to the carboxyl group, and cardol (*C*), a resorcinol derivative with a similar side-chain. Smith[2] showed that the unbranched side-chain consisted of 15 carbon atoms and 2 double bonds: other workers[3] have shown that the oily liquid is really a mixture of saturated and mono-, di-, and tri-olefinic compounds in proportions that give, on average, about two double bonds per molecule. Although the surface-active properties of the sulphonated shell liquid have already been studied[4], no thorough investigation has yet been carried out on anacardic acid, which, being an arylalkyl surfactant and a promising bactericidal agent, needs special attention[5]. Results of a preliminary study on sodium anacardate as a surfactant and bactericidal agent are reported here.



(*A*)



(*B*)



(*C*)

Shell liquid extracted with 95 per cent ethyl alcohol was saponified and the non-saponifiable material was removed by extraction with ethyl ether. Stage-wise liberation of cardol and then of anacardic acid (followed by separate extractions with ethyl ether), was carried out by passing carbon dioxide and treating the solution with dilute hydrochloric acid respectively. Dark brown anacardic acid, obtained after evaporation of the ether, and purified by charcoal treatment, had the following characteristics: specific gravity (30° C.), 1·0001; refractive index (40° C.), 1·5205; iodine value (Wij, 30 min.) 177·0 (this includes halogen substitution in the aromatic ring); iodine value determined by the corrected method of Kale and Kamath[6], 124·4. On the basis of the average molecular weight of anacardic

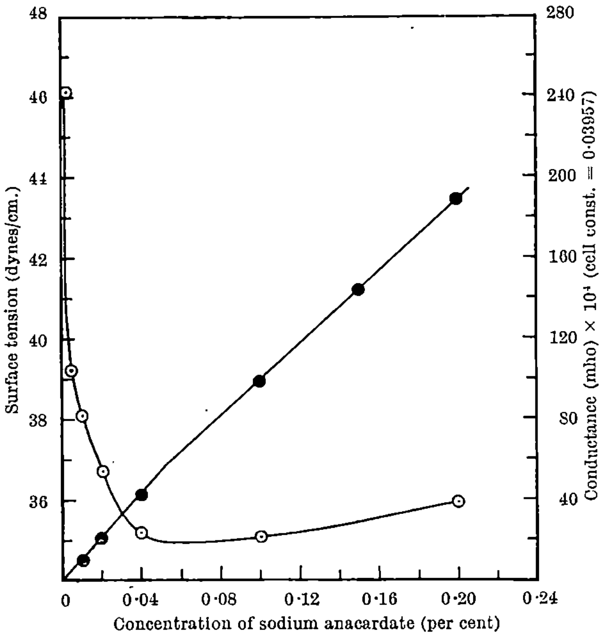


Fig. 1. ⊙, Surface tension ; ●, conductance

acid being 344, this gives an average of 1·686 double bonds per molecule.

On hydrogenation in the presence of a platinum catalyst a 95 per cent yield of white tetrahydroanacardic acid (m.p. 91·0° C.) was obtained. An alcoholic solution of anacardic acid was neutralized with slightly less than the requisite amount of alcoholic sodium hydroxide. After evaporation of most of the alcohol, the thick solution was poured into dry acetone, when the disodium salt precipitated out; this was filtered off, washed with dry acetone and dried *in vacuo*. The various surface-active properties of sodium anacardate were as follows :

(*a*) Surface tension at 25° C. (determined by Du Nuoy's tensiometer) of a 0·1 per cent solution was 35·1 dynes/cm. The surface tension/concentration curve showed a minimum in the concentration range 0·02–0·1 per cent (Fig. 1).

(*b*) The conductances of solutions of varying concentration were determined at 25° C. using a conductance meter unit, model No. 263941, Leeds and Northrup Co. The break of the specific conductance concentration curve at 0·053 per cent (Fig. 1) corresponds to the value of critical micellar concentration.

(*c*) While the interfacial tension of water against *n*-heptane was 51·24 dynes/cm. at 25° C. (Du Nuoy's tensiometer), 0·01, 0·02, 0·05 and 0·10 per cent sodium anacardate in aqueous solution lowered the value to 30·47, 20·07, 8·88 and 4·49 dynes/cm. respectively.

(*d*) 15 ml. of a 0·1 per cent solution when shaken with a 5 ml. *n*-heptane in a 25 ml. stoppered measuring cylinder (height 13 cm. and internal diameter 1·75 cm.) for 1 hr. in a shaker which had an amplitude of vibration of 11 cm. and imparted on the average 110 to-and-fro motions per minute. This emulsified the hydrocarbon almost completely. The volumes of aqueous and emulsion layers after intervals of 5 min. and 3 hr. were 13·8 ml., 5·8 ml. and 14·50 ml. and 5·10 ml. respectively. Average surface areas per unit volume of oil droplets, in 150 min.- and 24 hr.-old emulsion samples, calculated from the size distribution of the oil droplets[7], were $2·839 \times 10^3$ cm.^{2}/c.c. and $2·005 \times 10^3$ cm.^{2}/c.c. respectively. The figures denote excellent emulsion stability.

(*e*) When 200 ml. of a 0·1 per cent solution were discharged from a pipette (internal diameter of nozzle 1 mm.) on to a cushion of 50 ml. solution of the same concentration placed at the bottom of a long cylinder (internal diameter 45 mm.), the average height of fall being 75 cm., the foam heights at 0 min. and 30 min. were 16·8 cm. and 15·1 cm. respectively.

(*f*) Phenol coefficients of sodium anacardate with reference to *B. typhosa* and *S. aureus* were found to be 1·07 and 4·00 respectively. The concentrations of sodium anacardate solutions needed to kill the micro-organisms were of the same order, the large difference in the two values being due to the relatively weak influence of phenol on *S. aureus*.

These observations, coupled with the fact that sodium anacardate does not irritate the skin, indicate its suitability as a bactericidal surfactant. The inferior surface-active properties of sodium tetrahydroanacardate suggest that the ethylenic bonds were largely responsible for the greater solubility in water and the superior surface-active properties of sodium anacardate. The details of the investigations will be reported elsewhere.

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Kinetic Isotope Effect in the Iodination of Aromatic Amines

We have determined the kinetic isotope effect in the iodination of many aromatic amines, amino-carbonic and aminosulphonic acids by comparing the iodination-rates of normal and deutero-compounds. The results are collected in Table 1, the isotope effect being the ratio of iodination-rate constants, k_H and k_D, of normal and deuterated compounds without any correction for percentage of substitution of H by D). Relative activity, A_r, is the ratio of the rate constant of the given compound to that of iodination of *m*-dimethylaminobenzenesulphonate ion taken as 1.

Table 1 shows that *m*- and *p*-dimethylaminobenzenesulphonates are iodinated without any isotope effect ($k_H/k_D = 1$). 2,4,6-trideutero-*m*-aminobenzoate ion is iodinated slightly more slowly than the light compound. The iodination of other amino compounds is connected with a considerable isotope effect.

Similar isotope effects are observed in other cases of electrophilic substitution in aromatic compounds[1–3].

Table 1

Substance M	Substitution of H by D (per cent)	k_H/k_D	Relative activity, A_r	Experimental conditions: initial molar concentrations, *p*H, temperature (deg. C.)
2,4,6-Trideutero-*m*-dimethylaminobenzenesulphonate ion	90	1	1	M 0·076; I_2 0·008; KI 0·04; 25°
4-Deutero-1-dimethylaminobenzene-3-sulphonate ion	61	1	1	M 0·0145; I_2 0·0072; KI 0·073; phosphate 0·064; *p*H 7·0; 25°
2,6-Dideutero-1-dimethylaminobenzene-4-sulphonate ion	90	1	0·2	M 0·027; I_2 0·005; KI 0·01; 25°
2,4,6-Trideutero-*m*-dimethylaminobenzoate ion	95	1·4	35	M 0·02; I_2 0·005; KI 0·4; 30°
2,4,6-Trideutero-metanilate ion	61	2*	0·02	M 0·133; I_2 0·015; KI 0·036; 35°
2,4,6-Trideutero-*m*-aminobenzoate ion	90	4·8	0·22	M 0·045; I_2 0·005; KI 0·05; 30°
,,	90	3	0·24	M 0·025; I_2 0·005; KI 0·05; phosphate 0·05; *p*H 7·2; 30°
2,4,6-Trideutero-aniline	86	3·5	5·4	M 0·05; I_2 0·005; KI 0·15; 25°
,,	86	4·0	15	M 0·02; I_2 0·004; KI 0·12; phosphate 0·025; NaCl 0·08; *p*H 7·6; 25°
2,4,6-Trideutero-methylaniline	95	3·2	110	M 0·01; I_2 0·002; KI 0·3; acetate 0·05; *p*H 5; 25°
2,4,6-Trideutero-dimethylaniline	89	3·0	120	M 0·01; I_2 0·002; KI 0·15; lactate 0·5; *p*H 3·5; 30°

* This value of k_H/k_D is probably much smaller than the real one, because the percentage of substitution in the preparation used was not high

In a discussion of these results it is necessary to take into consideration the form of the general kinetic equation of iodination of aromatic amines[4], namely:

$$-\frac{d(I)}{dt} = k[M]^2[X] + k'[M][X][B] \qquad (1)$$

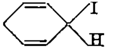
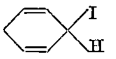
where M is an aromatic amine, X iodine cation or molecular iodine and B a basic component of the added buffer salt.

Equation (1) suggests that the activated complex of the reaction contains a base in the form of B or the second molecule M. One may suppose that the base acts as a proton acceptor in substitution in the benzene nucleus. However, the absence of isotope effect in iodination of dimethylaminobenzenesulphonate ions rules out this mechanism, at least in this case, because this assumption requires the proton elimination reaction as rate-determining step.

The alternative is that iodinating agents act in the form of complexes with bases $X \cdots M$ or $X \cdots B$, but that the hydrogen-splitting step does not limit the reaction-rate.

One could explain the isotope effect in iodination of other amines by supposing that bases act in these cases as proton acceptors; but considering the very great similarity of kinetic relations in iodination of various amines, we think that in all cases of iodination the base reacts in the form of a complex with I^+ or I_2. This assumption is supported by the consideration that the concentrations of (hydrated) iodine cation in the presence of potassium iodide are extremely small. Using Bell and Gelles data[5], it is easy to calculate that the iodine cation concentration in our experiments was as low as 10^{-14}–10^{-15} M. These concentrations cannot account for the observed rates of iodination of the most active amines.

At present, we cannot explain positively the established differences in k_H/k_D values in the iodination of aromatic amines. Table 1 shows that there is no connexion between the isotope effect and the iodination-rate. Indeed, the cases of presence or absence of isotope effect belong equally to high and to low values of A_r.

Grovenstein and Kilby[2] think that isotope effect in aromatic substitution is connected with the formation of stable intermediates having quinonoid structure, for example, O =  in the iodination of phenol, but the discovery of the isotope effect in the iodination of tertiary amines leads to the conclusion that the positively charged complexes $R_2\overset{+}{N}$ =  can also lose a proton as the rate-determining step.

However, the structural possibility of the formation of such intermediates is insufficient for the appearance of an isotope effect because, as we have seen, the introduction of a sulphonic group into the molecule of a tertiary aromatic amine results in disappearance of this effect. Apparently one must take into account the energetic pecularities of a reacting aromatic molecule.

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Crystalline Sodium Hyaluronate

Most hyaluronates in living tissues are in the form of protein complexes. Physical-chemical investigations on these complexes yield results which differ, depending on the source of the material and also on the extent to which the hyaluronic acid was purified of proteins[1]. It appears necessary that, in addition to the descriptions of the divergences of these complexes, one should investigate the nature of the complexing itself. Two views are prevalent in this matter. Noguchi[2] advocates a pure electrostatic interaction between protein and polyuronide, and Partridge[3] believes that the polyuronides have an orienting effect on proteins upon complexing. The last view presupposes certain stereospecific interactions besides electrostatic forces. Although hyaluronates are known to be birefringent and electron-microscopic investigations indicate a fibril structure[4], X-ray diffraction studies have so far proved that hyaluronic acid films or fibres are of amorphous nature.

Sodium hyaluronate was isolated from umbilical cords by a combination of processes (pepsin and trypsin digestion, Sevag process, extraction of sulphated polyuronides with ammonium sulphate and pyridine, final removal of protein by Lloyd's reagent). The resulting material was homogeneous

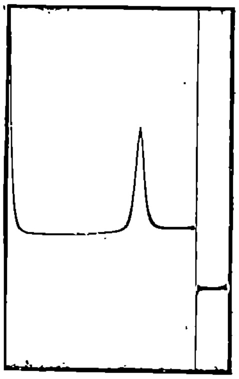

Fig. 1. Sedimentation pattern of sodium hyaluronate in 1 per cent aqueous sodium chloride solution

as observed in ultracentrifuge (Fig. 1), and had a weight-average molecular weight of 70,000. This low molecular weight, as compared to 1–4 million obtained by other authors[5] indicates that the complete removal of proteins from the preparation is achieved only at the expense of the hyaluronate chain. Although glucuronic acid and sodium were present in the preparation close to the theoretical amounts, both micro-Kjeldahl nitrogen and photocolorimetric analysis of N-acetyl glucosamine indicated that beside depolymerization a loss of nitrogen might have occurred to the extent of at least 10 per cent. However, the preparation was free from proteins and from sulphate-containing polyuronides.

Sodium hyaluronate dried from ethanol precipitation and humidified to 10 per cent moisture content yielded a highly crystalline powder diagram with as many as 22 observable reflexions (Fig. 2). The two different exposure times on the photograph were employed to show the higher order of reflexions. Detailed crystallographic analysis of the structure of sodium hyaluronate will be published shortly.

The fact that sodium hyaluronate containing approximately 3 per cent of protein (sample from the last purification step) yields an amorphous X-ray diagram indicates that the protein is strongly bound to the polyuronides, being attached at frequent spacings, and therefore, it disrupts the three-dimensional lattice array even if it is present in small quantities.

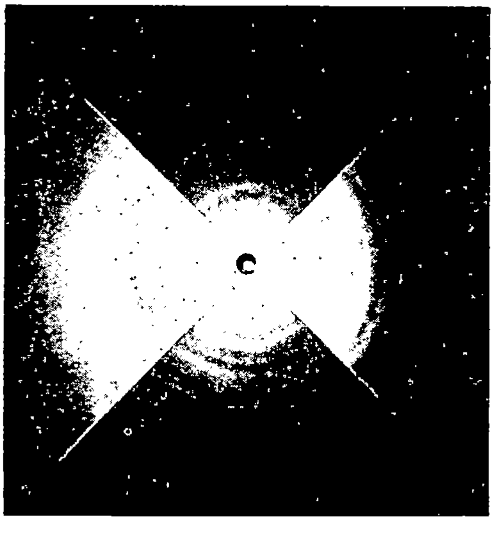

Fig. 2. X-ray powder diagram of sodium hyaluronate. Copper $K\alpha$ radiation. Camera distance, 5 cm. Reduction, 1/2

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Changes in Ultra-Violet Absorption Spectra of Deoxyribonucleic Acid by Treatment with Bromine

IN 1947, a procedure was developed[1] for the determination of pyrimidine nucleoside in which bromination and prolonged acid hydrolysis precede the performance of Bial reaction. More recently, it was also shown that marked changes in ultra-violet absorption spectra, particularly disappearance of selective absorption of cytosine, uracil and their nucleosides, occurred before and after the bromination of the compounds[2]. While studying the effects of bromine on the chemical nature of nucleic acids, we have also found that the maximal absorption of deoxyribonucleic acid shows a decrease with increasing bromination period. In further experiments, it has also been demonstrated that acid hydrolysis of brominated deoxyribonucleic acid results in a loss of selective absorption without significant loss of phosphorus.

White fibrous sodium deoxyribonucleate of herring sperm giving a negative biuret test was prepared[3] by deproteinization[4] from a commercial one (Minophagen Pharm. Co., Ltd., Tokyo). The preparation showing the analytical data of 8·6 per cent for phosphorus[5] and 14·9 per cent for nitrogen (Kjeldahl–Parnas) was used throughout this study. 60 ml. of 0·3 per cent sodium deoxyribonucleate solution and an equal volume of 2 per cent bromine water preincubated separately at 37° C. for 10 min. were combined in a tightly glass-stoppered flask. Immediately after mixing, the reaction mixture was incubated at 37° C. with occasional shaking. 10-ml. aliquots withdrawn at intervals were vigorously aerated for 3 min., when the solution became almost colourless. A few drops of diluted aqueous ammonia were then added to eliminate free bromine completely and to adjust *p*H at around 6. Mixtures thus treated were transferred to each 'Cellophane' bag for dialysis against running tap water (below 12° C.) for 2 days then against frequent changes of distilled water in the cold until no ammonium salt could be detected (Nesseler test) in the dialysate (about 3 days were needed). Inside liquid and washings were combined and distilled water was added to a final volume of 20 ml. 10-ml. portions of each solution were adjusted at *p*H 1·5 (glass-electrode) by dropwise addition of 2 *N* hydrochloric acid, when little or no turbidity occurred with brominated deoxyribonucleic acid whereas prompt precipitates arose with non-treated ones. After 30 hr. incubation at 37° C., solutions were placed in each 'Cello-

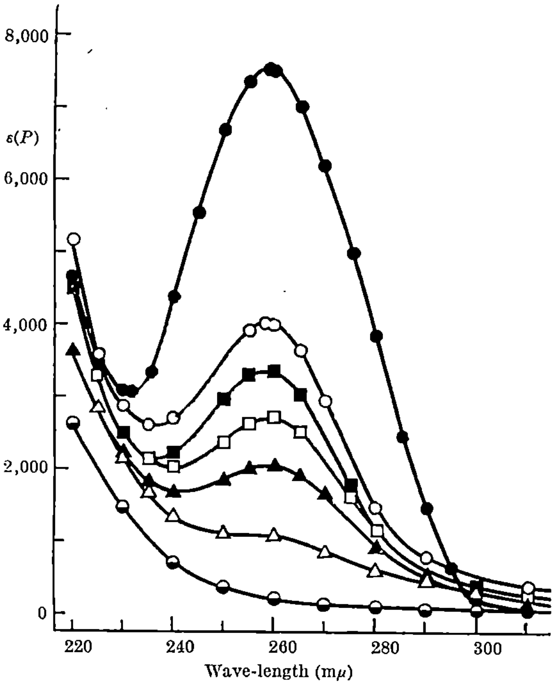

Fig. 1. Ultra-violet absorption spectra of brominated deoxyribonucleic acid in 1/15 *M* phosphate buffer of *p*H 7·0. Bromination period: 0 (original acid), —●—; 1·5 min., —○—; 3 min., —■—; 1 hr., —□—; 2 hr., —▲—; 5 hr., —△—; 12 hr., —⊖—

phane' bag to dialyse as mentioned above and the final volume was made up to 20 ml. by the addition of distilled water. Solutions thus treated were then measured for ultra-violet absorption spectra with a Beckman-type spectrophotometer, phosphorus according to Fiske and Subbarow[6] and nitrogen by the method of Kjeldahl–Nesseler[7].

From Fig. 1, showing typical changes in absorption spectra resulting from the bromination of deoxyribonucleic acid, no major shift will be seen in the absorption maxima so long as the acid was treated for a short time; however, ε(*P*) decreased with the increase of time to a complete loss of the selective absorption. Furthermore, as depicted in Fig. 2, the remaining absorption of brominated deoxyribonucleic acid was completely removed by the treatment with hydrochloric acid. Since the brominated acid was hydrolysed under the same conditions as employed for the preparation of apurinic acid and compounds, the spectra of which are given in Fig. 2, and had a nitrogen content similar to that of apurinic acid (N : P = 0·55)[3], it may be concluded that the pyrimidine moiety in brominated deoxyribonucleic acid was not liberated upon hydrolysis under the conditions employed and hence, extinction of brominated deoxyribonucleic acid was contributed by the purine moiety. On the other hand, diminution of nitrogen content was accompanied by the abatement of extinction with increasing bromination period. However, short bromination lessened markedly the absorption without significant loss of nitrogen. Decrease in quantity of nitrogen may be caused by the acidity of bromine water as a result of the liberation of purine bases. In all cases, the recovery of phosphorus was almost quantitative (more than 90 per cent) and the colour yield of the reaction of brominated deoxyribonucleic acid with diphenylamine[8] did not decrease within 20-min. bromination when comparison was made on the basis of phosphorus content.

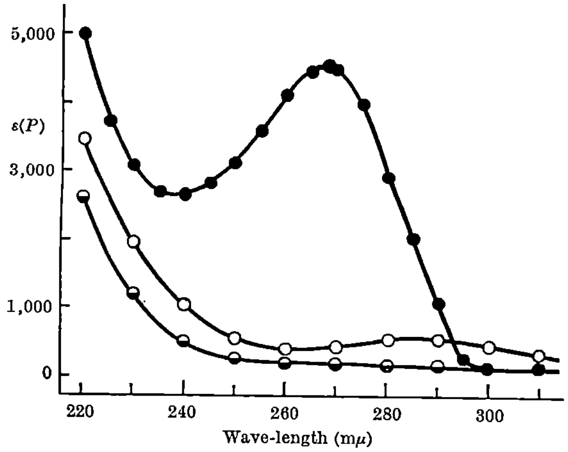

Fig. 2. Ultra-violet absorption spectra of brominated deoxyribonucleic acid hydrolysed with hydrochloric acid (in 1/15 *M* phosphate buffer of *p*H 7·0). Bromination period; 0 (apurinic acid), —●—; 1·5 min., —○—; 12 hr., —⊖—

Although the mode of action of bromine on deoxyribonucleic acid still remains uncertain, these results clearly indicate that bromine exerts a distinct influence particularly on the ultra-violet absorption spectra, and deoxyribonucleic acid gives a derivative devoid of any absorption characteristics of nucleic acids by a short bromination followed by mild acid hydrolysis.

Yeast ribonucleic acid showed rather different behaviour from deoxyribonucleic acid towards bromine treatment. Further work is now in progress and details will be published elsewhere.

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Preparation of Kojibiose

PREVIOUSLY, we detected kojibiose (2-O-α-D-glucopyranosyl-D-glucopyranose) in *sake* and its *moromi* and isolated it from a mixture of oligosaccharides synthesized from maltose and glucose by the culture filtrates of *Aspergillus oryzae*[1], *Asp. niger*[2] and *Schizosaccharomyces pombe*[3]. It was also isolated from hydrol[4]. Sato and Aso[5] crystallized it as α- and β-octaacetates, and Matsuda[6] and Haq and Whelan[7] synthesized it chemically.

The proportion of kojibiose in the sources was very small. Moreover, the separation of kojibiose from other disaccharides, especially *iso*maltose, by preliminary carbon column chromatography, was very difficult, as was its synthesis.

This communication deals with the preparation of kojibiose. Previously, it was reported[8] that when the dextran-producing organism *Leuconostoc mesenteroides* is grown on a medium containing sucrose, in the presence of large amounts of 1,4-α-linked glucose polymers, 1,6-α-linked oligosaccharides are produced in appreciable quantities. A particularly interesting example was that of Bailey *et al.*[9], who isolated, by charcoal chromatography, a new trisaccharide from a culture of *Betacoccus arabinosaceous* (Birmingham strain), which had been grown on a medium containing yeast extract, inorganic salts, sucrose and lactose. They determined its structure as O-β-D-galactopyranosyl-(1 → 4)-O-[α-D-glucopyranosyl-(1→2)]-D-glucopyranose. They reported that cleavage of the β-linkage in the trisaccharide by almond β-glycosidase was extremely slow, and that some 50 per cent of the trisaccharide remained after three weeks. They did not isolate kojibiose in a crystalline form.

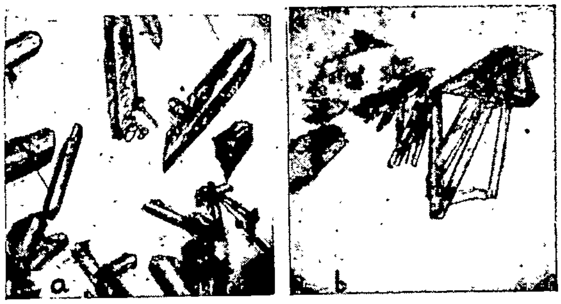

Fig. 1. *a*, α-Kojibiose octaacetate ; *b*, β-kojibiose octaacetate

Considering the structure, if the 1,4-β-linkage (lactose) in the trisaccharide is cleaved by *Saccharomyces fragilis* lactase, kojibiose and galactose will be easily obtained. By this method we obtained kojibiose in almost theoretical yield.

A culture of *Leuconostoc mesenteroides* (dextran-producer) instead of *Betacoccus arabinosaceous* (Birmingham strain) was prepared in a medium containing the following ingredients per l.; sucrose 30 gm., lactose 100 gm., ammonium sulphate 0·6 gm., potassium phosphate 5 gm., sodium chloride 1 gm., magnesium sulphate 0·2 gm. and yeast extract 1 gm. The inoculated medium was incubated for 10 days at 27–28° C. The formation of the trisaccharide was detected by paper chromatography and it was isolated by carbon-column chromatography. The yield was 46 gm. from the culture medium (10 l.).

0·5 gm. of the lactase preparation of *Saccharomyces fragilis*[10] (kindly supplied by Dr. Henry Roberts) and 10 gm. of the trisaccharide were added to 100 ml. of 0·067 *M* phosphate buffer, *p*H 6·2. This solution was incubated at 35° C. for 30 hr. Galactose, kojibiose, a trace of glucose and the trisaccharide were detected by paper chromatography. 5 gm. of kojibiose were isolated by carbon-column chromatography. By acetylation with acetic anhydride and sodium acetate, crystals of the α- and β-octaacetates of kojibiose were obtained. The α-form had m.p. 166° C. (yield 1·7 gm.); the β-form had m.p. 117–118° C. (yield 3·5 gm.). Further, by acetolysis of 10 gm. of the trisaccharide with acetic anhydride (50 ml.), glacial acetic acid (32 ml.) and concentrated sulphuric acid (6 ml.) at room temperature for 7 days, 0·4 gm. of α- and 0·8 gm. of β-kojibiose octaacetates were obtained in crystalline form.

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Origin of the Methoxyl Groups in Spirilloxanthin—a Carotenoid synthesized by the Photosynthetic Bacterium *Rhodospirillum rubrum*

It can now be stated with a reasonable assurance that the repeating (isoprene) unit of all terpenoid compounds arises from two-carbon (acetate) units via mevalonic acid (β,δ-dihydroxy-β-methylvaleric acid) or a closely related compound[1]. Occasionally, however, additional carbon atoms appear the origin of which cannot readily be referred to an isoprene unit; this is most marked in the plant sterols and perhaps the best example is ergosterol with its additional methyl substituent at C_{24}. It has been shown that this group arises by means of the transfer of a one-carbon unit from a donor such as active methionine or formyl- or hydroxymethyl-tetrahydrofolic acid, because formate-^{14}C is readily and specifically incorporated into C_{28} of ergosterol in yeast[2].

The only carotenoids which are known to contain such 'supernumerary' groups are those predominating in the photosynthetic bacteria. These have methoxyl groups attached to either positions 3 and 3′ or 4 and 4′; the best known pigment of this type is spirilloxanthin[3] (Fig. 1), which represents more than 95 per cent of the total carotenoids in mature cultures of *Rhodospirillum rubrum*[4]. Experiments have now been carried out which demonstrate that the methoxyl carbons of spirilloxanthin arise from a one-carbon unit and not from a degraded two-carbon unit.

Young anaerobic cultures of *R. rubrum* contain a mixture of carotenoids, the major components being lycopene, lycoxanthin (3-hydroxylycopene), *P*-481 and hydroxy *P*-481 (pigments of undecided structure but which must be intermediate between lycopene and spirilloxanthin) and spirilloxanthin[4]. If such

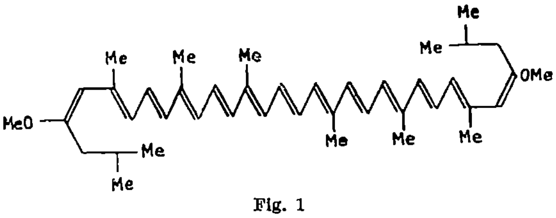

Fig. 1

cultures are washed and resuspended anaerobically in phosphate buffer, additional spirilloxanthin is synthesized while the remaining pigments disappear; the amount of spirilloxanthin formed is stoicheiometrically equivalent to the amount of the other pigments disappearing[5]. These observations strongly suggest that lycopene is converted into spirilloxanthin via *P*-481, etc., as intermediates. If direct methylation occurs during this transformation then addition of a labelled one-carbon compound to washed young cells should yield spirilloxanthin labelled only in the methoxyl groups. Consequently, 36-hr. anaerobic cultures grown under our standard conditions[6] were washed and resuspended anaerobically in the light in *M*/15 phosphate buffer (*p*H 7·0) to which had been added formate-^{14}C. 24 hr. later the cells were harvested, the spirilloxanthin extracted, purified chromatographically[6] and diluted with unlabelled crystalline spirilloxanthin isolated previously from large-scale cultures of *R. rubrum*. The pigment was then recrystallized from benzene to constant specific activity and the methoxyl groups oxidized to methyl iodide using standard micro procedures; the methyl iodide was trapped in freshly distilled quinoline[7]. Approximately 51 per cent of the total activity in the spirilloxanthin was found to be located in the trapped methyl iodide. Allowing for possible losses in the degradation of the pigment and in trapping the methyl iodide, this result leaves no doubt that formate is specifically incorporated into the methoxyl carbons of spirilloxanthin; a random distribution would have yielded less than 5 per cent of the total counts in the methoxyl carbons. Furthermore, the adequacy of the degradation from the isotope point of view was demonstrated by degrading a highly active sample of β-carotene, a carotenoid which contains no methoxyl groups; only 0·16 per cent of the added label was recovered in the quinoline-trapping agent.

Although it has not been possible to demonstrate directly that it is a methyl group rather than a methoxyl group which is transferred, the first possibility is much more likely because (*a*) transmethylation is a well-known and widespread biochemical reaction while transmethoxylation has not yet been reported and (*b*) probable hydroxylated methyl acceptors such as lycoxanthin, hydroxy *P*-481 and 'demethylated' spirilloxanthin[6,8] are present in young *R. rubrum*.

The occurrence of O-methylation in the carotenoids also fits in with the work of Birch *et al.*[9], who found that the methoxyl (and methyl) groups of the benzene ring of mycophenolic acid produced by *Penicillium brevi-compactum* arise similarly by one-carbon transfer, in this particular case from the S-methyl group of methionine.

Only about 25 per cent of the total formate incorporated into the unsaponifiable matter of *R. rubrum* is present in spirilloxanthin. Apart from the carotenoids, the nature of the other unsaponifiable components of *R. rubrum* is unknown but sterols do not appear to be present. It is interesting that formate is rapidly incorporated into this unknown fraction.

A question which still remains to be answered is, why the photosynthetic bacteria methylate their xanthophylls. Xanthophylls are abundant in all other photosynthetic organisms (higher plants and algae) but there is no indication that they are ever methylated[10].

We wish to thank Prof. A. J. Birch for a generous gift of formate-^{14}C and Dr. W. B. Whalley for arranging for the methoxyl determinations to be carried out in the Department of Organic Chemistry of the University of Liverpool.

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Electrophoresis of Fluorescent Antibody

A COMPLICATION often encountered in the use of the fluorescent antibody technique of Coons and Kaplan[1] is the presence of non-specific staining material in the conjugates, even after exhaustive dialysis. Apart from its nuisance-value, the effect is of interest because it does not occur when fluorescein-globulin reacts with sections of various malignant tissues[2,3].

A number of methods have been suggested for diminishing non-specific staining. Coons and Kaplan[1] used absorption with acetone-dried powders of certain tissues. It has also been found possible to isolate specifically staining fluorescent antibody by absorption to and elution from columns of antigen coupled powdered cellulose (unpublished work). These methods are of uncertain reproducibility, working well with some antibodies and tissues, but not with others. This communication presents some preliminary results of a physico-chemical study on fluorescein-protein conjugates, made in the hope of gaining more information about the chemistry of non-specific staining.

The electrophoresis pattern (Fig. 1) of fluorescein-conjugated human γ_2-globulin (8 μgm. fluorescein/mgm. of protein) shows marked heterogeneity. The spike has a mobility of $-1·46 \times 10^{-5}$ sec.$^{-1}$ V.$^{-1}$ cm.^{2} in sodium diethylbarbiturate buffer (*p*H 8·6, *I*, 0·1). A tracing of the ascending boundary of this pattern is superimposed in Fig. 2 on that of normal γ_2-globulin (mobility, $-1·01 \times 10^{-5}$ sec.$^{-1}$ V.$^{-1}$ cm.^{2} in sodium diethylbarbiturate buffer, *p*H 8·6, *I*, 0·1).

If the conjugate is shaken with acetone-dried rat liver powder[1] in phosphate buffer (*p*H 7·2, *I*, 0·1) a reduction in the area of the leading peak is observed (Fig. 3). If the γ_2-globulin was prepared from sera of

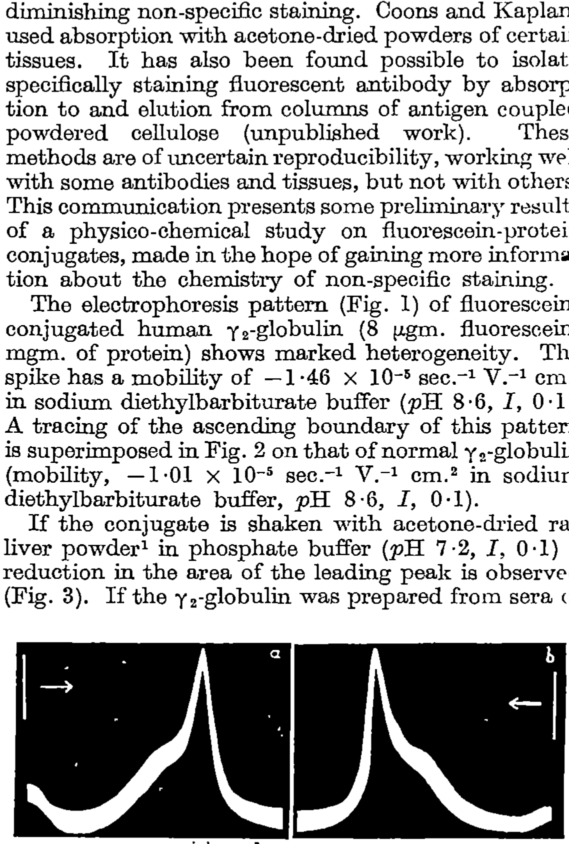

Fig. 1. Electrophoresis of fluorescein-conjugated human γ_2-globulin in sodium diethylbarbiturate buffer (*p*H 8·6, *I* 0·1). *a*, ascending, *b*, descending. The vertical line and arrow indicate origin and direction of migration in each case

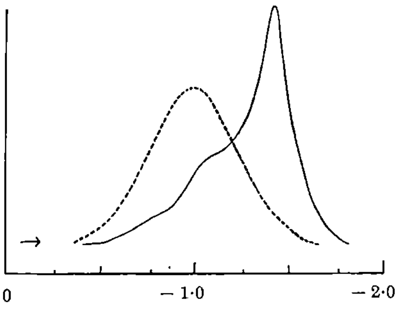

Fig. 2. Tracing of the ascending boundary of Fig. 1 superimposed on that of normal γ_2-globulin (broken line) in sodium diethylbarbiturate buffer (pH 8·6, I 0·1)

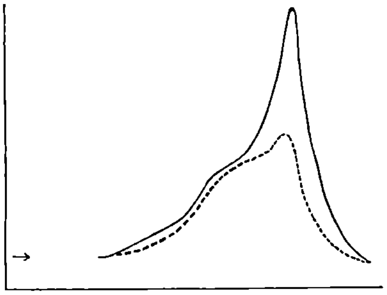

Fig. 3. The ascending electrophoresis pattern of rat liver powder-absorbed fluorescein-rabbit γ_2-globulin superimposed on that of unabsorbed fluorescein globulin (broken line). Electrophoresis in sodium diethylbarbiturate buffer (pH 8·6, I 0·1)

rabbits hyperimmunized against ovalbumin (domestic fowl) this marked diminution was associated with a loss of only 25 per cent of the antibody activity, as determined by diffusion in agar[4]. In contrast to the unabsorbed conjugates the absorbed material gave very little non-specific staining under the fluorescence microscope when applied to smears of leucocytes from normal human blood.

Attempts at separating the antibody from the non-specific staining activity by electrophoresis with starch blocks and powdered cellulose supporting media proved disappointing. An appreciable portion of the fast non-specifically staining material tailed during the run and was eluted with the antibody fraction.

However, it was possible to fractionate the fluorescein-globulin conjugate by electrophoresis convection. A 3 per cent solution of fluorescein-rabbit γ_2-globulin (containing anti-ovalbumin) was subjected to electrophoresis convection in an apparatus after the design of Raymond[5] at 20 V. cm.$^{-1}$ in six stages in phosphate buffer from pH 8·0 to 5·5 (I, 0·1), the pH being lowered by 0·5 at each stage. The assays of the top fraction from each stage are given in Table 1. It can be seen that the first two stages contain high-titre fluorescent antibody with no non-specific staining properties, and that the last fractions are the most heavily conjugated.

Table 1. ASSAY OF FLUORESCEIN-GLOBULIN FRACTIONS OBTAINED BY ELECTROPHORESIS-CONVECTION

Fraction	1 (pH 8·0)	2 (pH 7·5)	3 (pH 7·0)	4 (pH 6·5)	5 (pH 6·0)	6 (pH 5·5)	Starting material
Protein conc. (mgm./ml.)	2	4	7	7	6	5	30
Fluorescein content (μgm./ml.)	3	8	17	31	63	51	240
Antibody titre	150	430	180	150	100	60	1,024
Non-specific staining	—	—	+	++	+++	+++	+++

These findings present another facet of the well-known heterogeneity of γ-globulin—in this case its heterogeneous chemical reactivity. It is interesting to note that human serum albumin and a relatively homogeneous myeloma globulin both increased in mobility, but only slightly in heterogeneity (estimated by reversible boundary spreading) on conjugation with fluorescein *iso*cyanate.

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Reconstruction of the Reaction Mechanism of Cytochrome Oxidase

PREVIOUSLY it has been generally believed that the substrates of the cytochrome oxidase system, such as p-phenylene diamine and hydroquinone, are only oxidized by cytochrome oxidase through cytochrome *c*. However, since p-phenylene diamine is fairly well oxidized by particulate cytochrome oxidase preparations in the absence of cytochrome *c*, whereas the other substrates, such as hydroquinone are not, Okunuki[1] has suggested that the reductant of the so-called Nadi-reaction can reduce not only cytochrome *c* but also cytochrome oxidase. This was confirmed spectrophotometrically by Smith[2].

Recently, we reported[3] several properties of our cytochrome *a* preparation and showed that dithionite-reduced cytochrome *a* is oxygenated rather than oxidized by oxygen in the absence of cytochrome *c*. We also showed that in the presence of a small amount of reduced or oxidized cytochrome *c* the oxygenated cytochrome *a* is rapidly oxidized. In this communication the reduction velocity of cytochrome *a* by p-phenylene diamine, hydroquinone, and ascorbic acid in a solution of a synthetic non-ionic detergent, 'Emasol' 4130[4] is reported. We also confirm the role of cytochrome *c* in the appearance of the cytochrome oxidase activity of cytochrome *a*.

Cytochrome *a* in 'Emasol' 4130 is readily reduced by the addition of 10^{-3} *M* p-phenylene diamine as measured by the change in optical density of the α-band. The velocity measured by the change in the γ-band is somewhat less, due to contamination of the oxygenated form. In contrast to the results of Smith, we find that hydroquinone and ascorbic acid can also reduce cytochrome *a*, though at a slower rate than p-phenylene diamine. In an initial 1-min. reaction and at a concentration of 10^{-3} *M* the percentage reduction of cytochrome *a*, measured by the change in its α-band, is 92 for p-phenylene diamine, 55 for hydroquinone and 39 for ascorbic acid. When measured manometrically in the absence of cytochrome *c*, none of these substrates caused any uptake of oxygen. However, addition of cytochrome *c* to the cytochrome *a* preparation causes a large oxygen uptake (Table 1).

On the other hand, when a trace of borohydride is added to decrease the concentration of oxygen in the

Table 1. Influence of Addition of Cytochrome *c* on the Cytochrome Oxidase Activity of Cytochrome *a* (Oxygen Uptake/10 min.)

System \ Substrate (10^{-2} *M*)	*p*-Phenylene diamine	Hydroquinone	Ascorbic acid
No addition	4 μl.	4 μl.	10 μl.
Cytochrome *a*	6	4	4
Cytochrome *a* + cytochrome *c* ($1\cdot4 \times 10^{-5}$ *M*)	104	126	80

cuvette, cytochrome *a* is oxygenated in aerobic conditions and reduced in anaerobic conditions by the addition of 10^{-4} *M* *p*-phenylene diamine.

When a trace of cytochrome *c* is added to either system, either form of cytochrome *a* is instantaneously oxidized (Fig. 1).

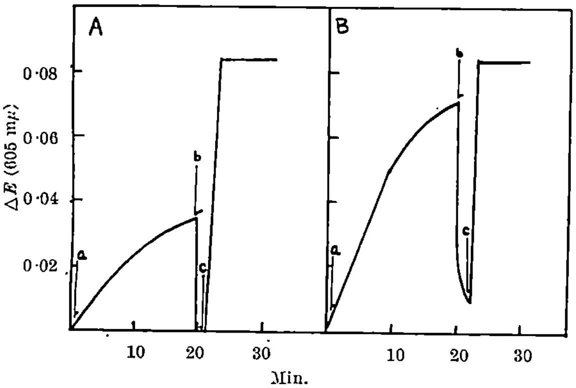
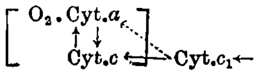


Fig. 1. Effect of cytochrome *c* on the oxidation of cytochrome *a*. Experiments conducted spectrophotometrically in a cuvette of 1 cm. light-path: *A*, cytochrome *a* incubated aerobically; *B*, anaerobically. Arrows indicate addition of each reagent: (*a*) 10^{-4} *M* *p*-phenylene diamine and trace of sodium borohydride; (*b*) 5×10^{-9} *M* of oxidized cytochrome *c*; (*c*) trace of sodium dithionite

Considering these findings in relation to those of Yakushiji and Okunuki[5] that electrons are also transferred from cytochrome *a* to cytochrome *c*, it seems that the electron in the hæm of cytochrome *a* does not participate in the cytochrome oxidase reaction unless cytochrome *c* is present in the system. The following scheme is therefore suggested to illustrate the reaction mechanism of cytochrome oxidase.

Cytochrome oxidase system :



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Preparation of Crystalline *Pseudomonas* Cytochrome$_{551}$ from *Pseudomonas aeruginosa*

Using a strain of *Pseudomonas aeruginosa*, we have already succeeded[1-3] in the purification of four kinds of respiratory components—*Pseudomonas* (*P*-) cytochrome oxidase containing the so-called cytochrome a_2, *P*-cytochrome$_{551}$, *P*-cytochrome$_{554}$ and *P*-blue protein—in forms soluble in water, without the aid of detergents. The crystallization of *P*-blue protein has been described[2]. Here the crystallization of *P*-cytochrome$_{551}$ is reported.

The principle used is as follows. (1) Extraction of the cytochrome from an acetone-powder of the cells. (2) Removal of viscous substances with acidic isoelectric points, such as nucleic acids, by the addition of rivanol. (3) Removal of substances with alkaline isoelectric points by treatment with 'Duolite' *CS*-101, which has similar properties to 'Amberlite' *XE*-64. (4) Rough fractionation of *P*-cytochrome$_{551}$ by chromatography on a column of specially buffered, activated aluminium oxide. (5) Fractionation by zone-electrophoresis on a column of raw potato starch. (6) Precipitation from ammonium sulphate solution, taking advantage of the great difference between the solubilities of the oxidized and reduced forms of the cytochrome.

The partial purification of *P*-cytochrome$_{551}$ by the first four steps has been described[1]. Using the resulting sample, zone-electrophoresis was carried out on a vertical column packed with potato starch (3 cm. in diameter, 30 cm. in height) under the following condition: 0·1 *M* sodium phosphate buffer, *p*H 7·0; current, about 20 m.amp. (350–400 V.); temperature, 4–5° C. The sample was placed in the middle of the column in a concentrated solution. Soon after the beginning of electrophoresis, a lot of brown impurities, not removed by treatment with rivanol, migrated downwards (anode) fairly rapidly, while the *P*-cytochrome$_{551}$ remained near the starting line. After 40 hr., the column was fractionated with the same buffer, using the same method as for normal resin columns. The brown impurities were eluted first and so could be removed easily. Nothing was eluted out after the cytochrome-containing fractions. The fractions of cytochrome were collected and their *E*(red.550·5)/*E*(oxid.275) ratios were found to be higher than 0·90 (this is the ratio of extinction at 550·5 mμ in the dithionite-reduced form to that at 275 mμ in the oxidized form).

The cytochrome collected was then oxidized by addition of the minimum amount of potassium ferricyanide, and precipitated with ammonium sulphate. The precipitate was washed with 80 per cent ammonium sulphate and dissolved in a small amount of distilled water (*E*(red.550·5), 40–60). Solid ammonium sulphate was added to the solution until it became slightly turbid (about 30–35 per cent saturation) and then it was immediately centrifuged. By this procedure, a small part of the cytochrome was precipitated, indicating a suitable concentration of ammonium sulphate for the following procedure. The deep red supernatant was reduced by the addition of a small amount of sodium dithionite, this reduction immediately causing a great increase in turbidity. After the yellowish-red solution had been kept overnight in a refrigerator, it was centrifuged. In most cases, the precipitate consisted of small, but fine needle-like crystals of *P*-cytochrome$_{551}$. The crystalline precipitate was dissolved in a small

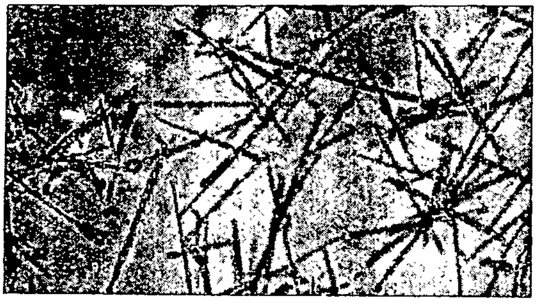

Fig. 1. Crystals of *Pseudomonas* cytochrome$_{551}$. (× 800)

amount of distilled water. After the re-addition of a trace of sodium dithionite, solid ammonium sulphate was added to give slight turbidity, with frequent adjustments of the *p*H to 7–8 with ammonia. The solution gradually increased in turbidity and the needle-like crystals shown in Fig. 1 began to appear after a few hours storage. The addition of the ammonium sulphate and the storage should be carried out at almost the same temperature, since the solubility of *P*-cytochrome$_{551}$ in ammonium sulphate solution increases greatly as the temperature decreases.

Twice recrystallized *P*-cytochrome$_{551}$ had the absorption spectrum shown in Fig. 2, and more than two recrystallizations did not increase its purity.

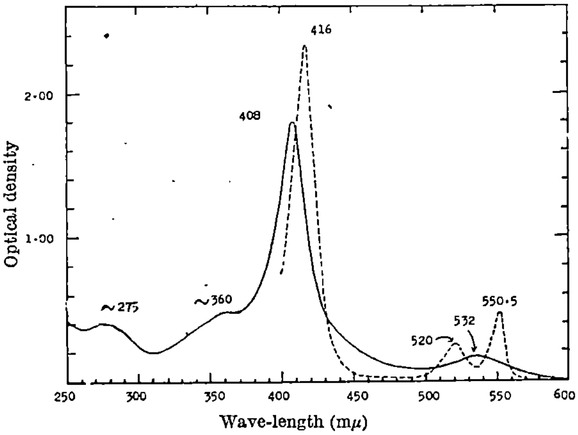

Fig. 2. Absorption spectrum of crystalline *Pseudomonas* cytochrome$_{551}$. ———, Oxidized form; – – – –, dithionite-reduced form. The numerals in the figure are the absorption maxima

Compared with crystalline cytochrome *c* prepared from bovine heart muscle[4,5] the α-absorption peak was at a slightly longer wave-length (about 0·5 mμ). The twice recrystallized sample of *P*-cytochrome$_{551}$ was homogeneous both by electrophoresis and by ultracentrifugal analysis.

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Action of Micrococcal Phosphodiesterase on Tobacco Mosaic Virus Nucleic Acid

Cunningham, Catlin and de Garilhe[1] were the first to report the occurrence of a calcium-activated nuclease in the culture medium of *Micrococcus pyogenes* var. *aureus*. These authors partially purified the enzyme and studied its action on deoxyribonucleic acid. In the complete digest they reported the presence of mononucleoside 3′-phosphates and also oligonucleotides. The latter were not identified except for one dinucleotide, deoxyadenylyl-(3′-5′)-deoxycytidine 3′-phosphate[2]. Recently, it was further demonstrated that this enzyme, when activated with calcium, hydrolyses ribonucleic acid[3].

This enzyme has been purified in this laboratory a hundredfold and its action on tobacco mosaic virus nucleic acid was studied. Our enzyme preparations also require calcium ion for activation. Among the reaction products formed after exhaustive digestion of tobacco mosaic virus nucleic acid with this enzyme the following mono- and di-nucleotides have so far been identified: adenosine 3′-phosphate; guanosine 3′-phosphate; cytidine 3′-phosphate; uridine 3′-phosphate; adenylyl-(3′-5′)-cytidine 3′-phosphate; adenylyl-(3′-5′)-guanosine 3′-phosphate; uridylyl-(3′-5′)-guanosine 3′-phosphate; and uridylyl-(3′-5′)-uridine 3′-phosphate; adenylyl-(3′-5′)-uridine 3′-phosphate; and uridylyl-(3′-5′)-cytidine 3′-phosphate. This enzyme has no action on purine or pyrimidine cyclic nucleotides, and hence the possibility of its cleavage of ribonucleic acid via transphosphorylation can be excluded. Full details of this investigation will be published elsewhere.

I wish to thank Dr. W. M. Stanley for his interest and Miss Patrice J. Driskell for supplying me with the organism used in these studies. This investigation was aided by grants from the Rockefeller Foundation and the United States Public Health Service.

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Isolation of $\Delta^{5,7,9}$-Œstratrienol-3-one-17 from the Urine of Pregnant Mares

$\Delta^{5,7,9}$-ŒSTRATRIENOL-3-ONE-17 was isolated from pregnant mares' urine in 1940 by Heard and Hoffman[1]. These workers obtained approximately 160 mgm. of pure material per 10,000 gallons of urine, that is, about 3·8 μgm./l., but stated that this did not represent the total quantity excreted. Since no other isolations of $\Delta^{5,7,9}$-œstratrienol-3-one-17 from pregnant mares' urine have been reported in the literature, we believe that it is of interest to record that we have found the material to be present in pregnant mares' urine in relatively large quantities (approximately 430 gm. of $\Delta^{5,7,9}$-œstratrienol-3-one-17 per 10,000 gallons of urine, that is, about 10 mgm./l.) and that we have isolated the material readily in the pure state.

A concentrate, representative of mares' urine collected from approximately the fourth to ninth month of pregnancy, was prepared by methods previously outlined by us[2]. The concentrate was subjected to hydrolysis and a non-phenolic ketonic fraction isolated which yielded, after acetylation, approximately 100 gm. of pure $\Delta^{5,7,9}$-œstratrienol-3-one-17 acetate on repeated crystallizations. This acetate had the following properties: m.p. 167–69° C.; $\lambda_{max.}$ (alc.) 269 mμ, $\varepsilon = 395$; $\bar{\nu}_{max.}$ (CS_2) 1,736 cm.$^{-1}$ and 1,242 cm.$^{-1}$ (acetate), 810 cm.$^{-1}$ (aromatic ring *B*). The infra-red spectrum was identical with that of a sample of $\Delta^{5,7,9}$-œstratrienolone acetate kindly supplied by the late Prof. R. D. H. Heard. On hydrolysis with perchloric acid in methanol at room temperature an 85 per cent yield of the free alcohol was obtained. This had a melting point of 146–49° C., and had bands in the infra-red (CS_2) at 1,741 cm.$^{-1}$ (17-ketone) and 811 cm.$^{-1}$ (aromatic ring *B*).

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Vitamin B_{12} Activity in the Serum of the Rat

A STUDY is being made in this Department on the metabolism of vitamin B_{12} in the albino rat, and on the effects of deficiency of this vitamin produced by dietary and other means. As part of this study, the possibility was investigated of using microbiological assays of vitamin B_{12} activity in serum to assess the nutritional state of the animals with regard to vitamin B_{12} in the same way as in human subjects. This communication describes preliminary results obtained on normal and gastrectomized rats and on rats which had been kept on a diet deficient in vitamin B_{12}.

Albino rats of the Wistar strain were used. Blood (1–2 ml.) was obtained by cardiac puncture and was allowed to clot in small test-tubes. The clots were broken up with glass rods, the samples were centrifuged, and the serum was removed and stored frozen until required for assay. The vitamin B_{12} activity in the serum was assayed by a method described by one of us[1], using *Lactobacillus leichmannii* as test organism. Owing to the small amounts of serum obtainable from rats, protein-free extracts were prepared from 0·4 ml. portions of serum, and assays were carried out at one dilution only, corresponding to 1 ml. of a 1 : 20 dilution of serum per 5 ml. of assay medium. Tests using larger amounts of pooled serum from various groups of animals showed that the values obtained using different dilutions of serum were the same within the limits of accuracy expected from microbiological assays. The method gave quantitative recoveries of vitamin B_{12} added to pooled rat serum (Table 2).

The results obtained in various groups of animals are shown in Table 1. It is evident that both gastrectomy and dietary deficiency of vitamin B_{12} can cause reduction in the vitamin B_{12} activity of the serum to subnormal levels, so that the estimation seems to be useful in deciding whether or not an animal is deficient in vitamin B_{12}.

Table 1. VITAMIN B_{12} ACTIVITY IN THE SERUM OF VARIOUS GROUPS OF RATS

Group	No. of animals	μμgm. vitamin B_{12} activity per ml. serum	
		Mean	Range
Normal	36	983	630–1,500
Gastrectomized (1–12 months after operation)	6	402	350–480
Animals fed a diet deficient in vitamin B_{12} for 6 months	4	515	460–560
Normal (assayed with *Euglena gracilis*)	6	150	100–180

Table 2. VITAMIN B_{12} ACTIVITY OF SAMPLES OF POOLED RAT SERUM BEFORE AND AFTER TREATMENT WITH ALKALI

Sample No.	Group of rats	μμgm. vitamin B_{12} activity per ml. serum	
		Before alkali treatment	After alkali treatment
1	Normal	1,400	460
2	Normal	1,200* 1,300*	550* 530*
3	Normal	830* 730*	450* 370*
3 + 1,000 μμgm. vitamin B_{12} per ml. added	Normal	2,000	420
4	Normal	770	460
4 + 1,000 μμgm. vitamin B_{12} per ml. added	Normal	1,900	490
5	Gastrectomized	430	410
6	Fed diet deficient in vitamin B_{12} for 6 months	610	510

* Results of separate assays on the same sample of serum.

The levels in both the normal and the deficient animals, however, are high compared with those found in normal subjects and patients with untreated pernicious anæmia respectively[2]. This appears to be because rat serum contains a substance which has vitamin B_{12} activity for *Lactobacillus leichmannii*, but which is stable to boiling for 30 min. at *p*H 12, a treatment which destroys vitamin B_{12} and almost all the vitamin B_{12} activity in human serum[1]. Table 2 shows the vitamin B_{12} activity of pooled sera from different groups of rats before and after boiling with alkali. While about 50 per cent of the activity in normal rat serum is destroyed, much less is destroyed in serum from gastrectomized rats and rats kept on a diet deficient in vitamin B_{12}. The alkali-stable fraction, however, is roughly the same in all the groups. This suggests that deficiency of vitamin B_{12} causes a gross depletion of true vitamin B_{12}, the alkali-labile fraction, but that the alkali-stable fraction is unaffected. When serum to which vitamin B_{12} has been added is treated with alkali, the activity remaining is virtually the same as that found after treating with alkali the same sample of serum without added vitamin B_{12} (Table 2).

Estimations of vitamin B_{12} activity were kindly carried out for us on the sera of 6 rats by Dr. W. M. Davidson of King's College Hospital Medical School, London, using *Euglena gracilis* as test organism. The results are included in Table 1. Although *Euglena* gives lower results than *Lactobacillus leichmannii* on human serum, the difference would not account for the discrepancy found with the rat sera, so that the alkali-stable fraction in rat serum may be inactive for *Euglena*. Experiments are in progress to determine the nature of the alkali-stable fraction.

We are grateful to Mrs. Beryl Godfrey and to Mrs. Elisabeth Ross for assistance with the microbiological assays, and to Prof. L. J. Witts for his interest in the

work, which was supported in part by a grant from the Medical Research Council to Prof. Witts.

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Effect of Hydrogen Peroxide on Transplanted Rat and Mouse Tumours

Recently, Holman[1] has reported that daily continued oral administration of commercial hydrogen peroxide (in drinking water) caused complete regression of Walker carcinoma 256 in rats in 50–60 per cent of the cases. This laboratory finding was applied in humans with advanced inoperable cancers. In two of the four cases there was reported a definite subjective and objective improvement[1]. The obvious importance of these findings in the case of a compound so plentiful made it desirable to attempt to confirm these results in Walker carcinoma 256 and in several of other animal tumours.

The tumours used in the present study were sarcoma 180, adenocarcinoma *E* 0771, Mecca lymphosarcoma, sarcoma ascites tumour and Ehrlich ascites carcinoma in mice, and Walker carcinosarcoma 256 in rats. The history, biological properties and cytological description of these tumours are given elsewhere[2].

Subcutaneous implantations of tumours were carried out by the usual trocar method. The progress of the tumours in the treated and the untreated animals was recorded graphically by measuring the diameters of the tumours with calipers at weekly intervals for four weeks after tumour transplantation. In the case of ascites tumours[3], intraperitoneal injection of 0·1 c.c. of the fluid containing about one million cancer cells was made into each mouse in the inguinal region. The animals were maintained on a standard pellet diet (Purina Laboratory Chow).

Animals implanted with various tumours were treated by simply replacing their drinking water with distilled water containing 0·3, 0·45 and 0·9 per cent by weight of hydrogen peroxide (U.S.P.). The dilute solutions of hydrogen peroxide were prepared daily. During the experiment, the drinking water-bottles were covered with a tinfoil. The hydrogen peroxide content of the diluted solutions remained practically unchanged after standing 24 hr. in an air-conditioned animal room. The control animals were given water *ad lib.*

The treatment with hydrogen peroxide was started in most cases 24 hr. after transplantation of the tumour, and treatment was continued for four weeks.

The degree of inhibition of the growth of the solid tumours was graded according to the following scheme:

–, No effect; tumour growth more than three-quarters the average diameter of the controls.

±, Slight inhibition; tumour growth from a half to three-quarters the average diameter of the controls.

+, Moderate inhibition; tumour growth from a quarter to a half the average diameter of the controls.

++, Marked inhibition; no tumour growth or growth to a quarter the average diameter of the controls.

The degree of ascites tumour growth was graded according to the following scheme:

–, No effect, indicating marked abdominal distention; the fluid volume increases to three-quarters or more of the controls (16–30 c.c.).

± Slight inhibition, indicating moderate abdominal distention; the fluid volume increases to about a half the volume of the controls (6–15 c.c.).

+, Moderate inhibition, indicating slight abdominal distention; the fluid volume increases to about a quarter the volume of the controls (1–5 c.c.).

++, Marked inhibition, indicating no abdominal distention; no gross ascites.

The results obtained with hydrogen peroxide at various dilutions are summarized below and in Tables 1 and 2. In the tables the average changes in weight in grams of treated over control animals after one week of treatment is recorded. Five or ten animals were used in each test group.

The results of the experiments showed that oral administration of 0·3, 0·45 and 0·9 per cent of hydrogen peroxide in drinking water had no inhibitory effect on the growth of sarcoma 180, adenocarcinoma *E* 0771, Mecca lymphosarcoma and Walker carcinosarcoma 256 in animals. Practically all tumours grew rapidly and killed animals in 2–5 weeks after tumour transplantation. In one experiment the effect of hydrogen peroxide on well-established 12-day-old Walker carcinosarcoma 256 was tested. The results of this experiment showed that daily doses of 0·45 per cent by weight of hydrogen peroxide in drinking water had no inhibitory effect on the

Table 1. Effect of Hydrogen Peroxide in Drinking Water on 1-day-old Mouse and Rat Tumours

Tumour	Hydrogen peroxide content (per cent)	Average hydrogen peroxide water consumed by animal/day (c.c.)	No. of deaths		Average weight change (gm.) treated/controls (1st week)	Results of treatment	
			1st week	2nd week		1st week	2nd week
Sarcoma 180	0·3	3·7	0/10	0/10	+ 2·3/+ 2·2	–	–
Sarcoma 180	0·45	2·1	0/10	1/10	+ 0·9/+ 0·9	–	–
Adenocarcinoma *E* 0771	0·3	2·2	0/10	0/10	+ 0·1/+ 0·5	–	–
Mecca lymphosarcoma	0·3	4·3	0/10	2/10	+ 1·8/+ 1·9	–	–
Walker carcinosarcoma 256	0·45	22	0·10	0/10	+ 29/+ 34	±	–
Walker carcinosarcoma 256	0·9	8·5	1/10	2/10	+ 3/+ 26	–	–
Walker carcinosarcoma 256 (12-day-old)	0·45	16	0/10	0/10	+ 1/+ 11	–	–

Table 2. Effect of Intraperitoneal Injections of Hydrogen Peroxide on 1-day-old Mouse Ascites Tumours

Tumour	Dose (mgm./kgm./day)	No. of deaths		Average weight change (gm.) treated/controls (1st week)	Results of treatment		
		1st week	2nd week		1 day	10 days	14 days
Ehrlich carcinoma	15	0/5	2/5	+ 6·4/+ 5·7	–	–	–
Ehrlich carcinoma	75	0/5	0/5	+ 3·8/+ 5·7	–	–	–
Ehrlich carcinoma	150	0/5	1/5	+ 3·0/+ 5·7	–	–	–
Sarcoma 180	150	0/5	1/5	+ 2·1/+ 6·8	–	–	–
Sarcoma 180	225	0/5	1/5	– 0·6/+ 6·8	+	+	+

tumour. All treated tumours grew normally. When the rats were given 0·9 per cent hydrogen peroxide in drinking water, they consumed less water, and therefore ingested an amount of hydrogen peroxide equivalent to that which was contained in 0·45 per cent hydrogen peroxide.

During the course of this work, we determined the effect of hydrogen peroxide on the growth of two different types of ascites tumours, namely, sarcoma 180 and Ehrlich carcinoma. Mice with these ascites tumours die in about fourteen days with large amounts of ascitic fluid. The first intraperitoneal injection of hydrogen peroxide solutions was given 24 hr. after intraperitoneal injection of about one million cancer cells, and the treatment was continued for seven days. From the results in Table 2, it is evident that doses less than 150 mgm./kgm./day of hydrogen peroxide had no inhibitory effect on the growth of either sarcoma 180 or Ehrlich ascites tumours. However, a higher dose of 225 mgm./kgm. of hydrogen peroxide had a moderate inhibitory effect on sarcoma 180 ascites tumour. Treatment of the well-established ascites tumours was less effective.

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Incorporation of Carbon-14 Dioxide by Duck Erythrocytes and Reticulocytes *in vitro*

PREVIOUS studies *in vivo* on the incorporation of carbon-14 dioxide from carbonate into rat erythrocytes have demonstrated that this is widespread into globin, hæmatin and ghosts[1]. Some fractions of rat blood rich in reticulocytes can also incorporate carbon dioxide *in vitro*[2].

This communication is concerned with the ability of duck blood rich in reticulocytes to incorporate carbon dioxide *in vitro*.

The blood was obtained in the following way: 30 mgm. phenylhydrazine per kgm. body-weight was dissolved in 10 ml. of saline and administered orally. After 48 hr. about 10 ml. of blood per kgm. body-weight was removed and discarded. After 92 hr. blood rich in reticulocytes was removed for incubation. 50 ml. of heparinized blood (10 mgm. per cent of heparin) was added to a saline solution of penicillin and streptomycin (about 3 mgm. per cent). 200 μc. of NaH^{14}CO$_3$ (1 mc./mmole) dissolved in 5 ml. of an isotonic solution containing 0·4107 gm. per cent of sodium carbonate and sodium chloride, and 0·3 per cent glucose was then added to the mixture. 10-ml. aliquots in 30 ml. vessels were incubated, with slow rotation in an atmosphere of 95 per cent oxygen and 5 per cent carbon dioxide for 20 hr. at 38·5 ± 0·1° C.

Hæmatin, globin stroma, and protoporphyrin were prepared by the method previously described[2], histone and deoxyribonucleic acid according to Allfrey *et al.*[3]. The total carbon content was determined according to Van Slyke *et al.*[4] and its activity was measured by the gas-phase counting method[1,2]. The results are shown in Table 1.

From these results it can be seen that there is considerable fixation of carbon from sodium bicarbonate during incubation of duck blood with sodium bicarbonate.

Table 1

Materials	Stroma	Globin	Hæm	Protoporphyrin	DNA	Histone
Specific activity (disintegrations/mgm. C/min.)	226	154	45·5	1,430	83	130

Error of experimental results less than 10 per cent

The uptake in our experimental conditions is of the order of a few parts per thousand. Because carbon fixation from sodium bicarbonate in biological systems takes place[5] after dehydration of carbonic acid in equilibrium with HCO$_3^-$, carboxylation reactions are obviously possible in the red cells of the duck.

The widespread incorporation into all the components of red cells we have analysed, suggests that the first products of carboxylation belong to a pool of substances from which all the substances we examined can be synthesized. They could be those of the Krebs cycle[5].

These first products will have a greater specific activity, since they are less diluted with similar labelled compounds. To these products we ascribe the large value of carbon-14 specific activity found in non-protein fractions of the plasma (800 disintegrations/mgm. carbon/min.) and in a hæmolysed fraction containing none of the substances in Table 1 (1,700 disintegrations/mgm. carbon/min.).

The fact that the specific activity of the protoporphyrin is greater than that of the hæm indicates that the protoporphyrin is mainly newly formed by young red cells *in vitro*[6].

The activity found in the globin shows that carbon dioxide is fixed in amino-acids; our present knowledge suggests that it is previously fixed in some keto-acids by carboxylation reactions, and that amino-acids are then formed by transamination. If this is also true for duck red cells, they will contain transaminases. The activity found in the hæm and in the protoporphyrin shows that carbon dioxide is previously fixed in succinate and/or glycine[7]. The specific activity in the hæm is approximately 30 times lower than in the protoporphyrin. From this it can be deduced that for a hæmoglobin concentration of 15 gm. per cent (that is, for a hæm concentration of 0·7 gm. per cent), approximately 20 mgm. of hæm was synthesized in 20 hr.

Adding iron as gluconate to the blood increased the relative specific activity of the hæm (Table 2), as though iron gluconate catalysed the formation of some hæm precursor or inhibited the synthesis of some amino-acid of the globin.

Activity found in the histone shows that there is a nucleoprotein turnover: this result does not conflict with that of Allfrey *et al.*[3], who found no detectable turnover in similar experiments with glycine-^{15}N, in view of the small glycine content of the histone[8] and the sensitivity of their apparatus. The activity found in the deoxyribonucleic acid could also be due

Table 2

Experiment	Relative specific activity	
	Globin	Hæmatin
A (no Fe^{++} added)	1	0·29
B (Fe^{++} added)	1	0·46

Table 3

Time (hr.)	Specific activity in disintegrations/min./mgm. carbon in			
	Globin	Hæm	Stroma	Protoporphyrin
1·5	38	14	41	3,700
3·0	40	18	54	
6·0	50	19	85	3,350
18·0	53	27	107	2,400

Error of experimental results less than 10 per cent

to a direct fixation of carbon dioxide in the purine ring[9].

The specific activity of the stroma was found to be greater than that of the hæmoglobin. This proves that the activity of the stroma is not due only to the residual hæmoglobin trapped; in effect both the protein and the lipid fractions can incorporate carbon dioxide.

Rate of uptake. Incubation was carried out at 38·5 ± 0·1° C. for 1·5, 3, 6 and 18 hr. in an atmosphere of 95 per cent oxygen and 5 per cent carbon dioxide. Samples of 15 ml. of blood from the same duck were mixed with 60 μc. $NaH^{14}CO_3$ (specific activity 1 mc./mole dissolved in 1·5 ml. of an isotonic solution). 0·7 mgm. of iron as gluconate, 50 mgm. of glucose, 1·25 mgm. each of sodium benzyl-penicillin and dihydrostreptomycin sulphate were also added. The preparation of the materials and the method of measuring the specific activity have already been described[1,2].

The results are shown in Table 3; specific activity values are plotted against incubation time in Fig. 1.

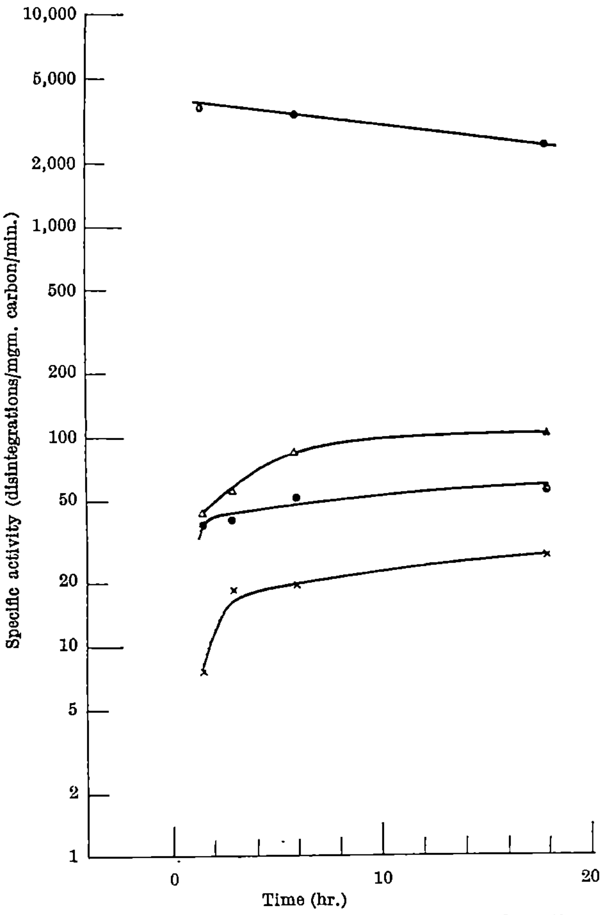

Fig. 1. ○, Protoporphyrin; △, stroma; ●, globin; ×, hæmatin

Carbon incorporation from sodium bicarbonate follows the same pattern, within experimental error, for globin and hæmatin: it can be deduced that the rate of hæmatin and globin synthesis is the same; that is, there is not a different turnover for the two substances. The decreasing rate after the first 4 hr. (in which 70 per cent of newly synthesized hæmoglobin is formed) may be due to a progressive deficiency of amino-acids. Our results on the rate of new synthesis of hæmatin are in good agreement with those reported by Shemin *et al.*[7] on the rate of incorporation of glycine-^{15}N by duck blood in similar experimental conditions.

Carbon uptake from sodium bicarbonate into stroma and into protoporphyrin is different from that seen in hæmoglobin. The specific activity of protoporphyrin decreases slightly with time: this may be due to dilution with less active protoporphyrin arising from the catabolism of the hæmatin.

Further experiments are in progress to extend these results.

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Development of Skeletal Muscle Protein

We have reported determinations of the actin and myosin in the skeletal muscle of a chick 72 [1,2] and 96 [3] hr. after incubation respectively. In order to test whether the appearance of actin in the developing skeletal muscle before the formation of myosin is limited to chick embryos or is a general phenomenon in animals I investigated the formation of actin and myosin in the embryonic stages, and in regenerating limbs after amputation at the knee, of *Triturus pyrrhogaster* using the same methods as before.

G-Actin and myosin were isolated from the skeletal muscle tissue of good-sized specimens of *Triturus pyrrhogaster* by the method of Szent-Györgyi[4]. Both proteins, at a concentration of 25 mgm./ml., were injected intravenously into rabbits at three-day intervals, until they reached a total of 100 mgm. The rabbits were bled by heart puncture on the fifth day after the last injection, and the sera obtained were raised to their serological specificity by resorption tests[5] with saline extracts of liver, spleen and skin tissue of *Triturus pyrrhogaster*. Titration with homologous antigen[6] was then carried out before the precipitin reaction with a saline extract of embryo or granulating tissue of amputated limbs. The titre of both sera was 1 : 512. A possible failure due to excess of antigen was prevented by using a constant volume of sera and progressively decreasing the amount of antigen.

It was found that actin and myosin first become detectable in the early embryo at stage 19 (about 132 hr. old at 20 ± 1° C.) and stage 24 (about 176 hr. old at 20 ± 1° C.)[7] respectively (Table 1). They were detected in the granula of regenerating limbs about 20 and 27 days after operation (Table 2) respectively, though DeHaan[8] reported a transient appearance of actomyosin in the regenerating limbs of *Amblystoma mexicanum* about 20 days after operation. His result may be due to a cross-reaction of his antisera with developing actin[9].

Table 1. DETERMINATION OF DEVELOPING SKELETAL MUSCLE PROTEIN IN EARLY EMBRYOS OF *Triturus pyrrhogaster*

Developmental stages	No. of embryos extracted	No. of reactions series	Lowest antigen concentration to give positive results*	
			Actin	Myosin
18	12	2	—	—
19	12	2	1 : 20	—
20	12	2	1 : 40	—
23	12	2	< 1 : 160	—
24	12	2		1 : 160
25	12	2		< 1 : 160
26	10	2		< 1 : 160
Control (non-fertilized)	24	2	—	—

* Antigen concentrations used ranged from 1 : 10 to 1 : 160 in embryos weight.

Table 2. DETERMINATION OF DEVELOPING MUSCLE PROTEIN IN REGENERATING LIMB OF *Triturus pyrrhogaster*

Days after operation	No. of granules extracted	No. of reactions series	Lowest antigen concentration to give positive results*	
			Actin	Myosin
18	10	2	—	—
20	10	2	1 : 20	—
22	10	2	1 : 160	—
25	10	2	< 1 : 160	—
27	10	2		1 : 10
29	6	2		1 : 40
31	6	2		1 : 160

* Antigen concentrations used ranged from 1 : 10 to 1 : 160 in tissue weight.

Therefore, it is probably generally true that in the skeletal muscle actin appears before the formation of myosin, both in the early stages of development and in regenerating tissue. On the other hand, in the heart muscle of early embryos, myosin appears before actin[1,2,10]. In view of this, the morphological and physiological characteristic differences between heart and skeletal muscle should be examined.

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Fungitoxic Action of 8-Hydroxyquinoline, Pyridine-N-oxide-2-thiol and Sodium Dialkyldithiocarbamates, and their Copper Complexes

IN a previous communication[1] on the mode of fungitoxic action on *Aspergillus niger*, we found that of the copper complexes of 8-hydroxyquinoline (oxine) and pyridine-N-oxide-2-thiol (PTO), the 1 : 2 complexes are toxic, but of the sodium dimethyldithiocarbamates (NaDDC) the 1 : 1 complex is toxic but 1 : 2 complex is not. We suggested that this discrepancy is not fundamental but can be explained simply by the difference in solubility of the complexes (Table 1). This hypothesis can now be substantiated by observations on the fungitoxic action on *Glomerella cingulata*, a more sensitive mould than *A. niger*. The experiments were carried out as described before[1], in shaken flasks with a basal medium of glass-distilled water and analytical grade reagents, the total copper content not exceeding the equivalent of 0·01 p.p.m. $CuSO_4.5H_2O$. We found that, unlike *A. niger*, *Glomerella cingulata* does not show 'inversion growth' with sodium dimethyldithiocarbamate and copper and, as could be expected on this ground, it is inhibited by copper dimethyldithiocarbamate ($CuDDC_2$) (Table 1). The toxic concentration of copper dimethyldithiocarbamate appeared to be somewhat higher than the concentration of a saturated solution[2], but this can be easily understood since the dissolution is a rather slow process. From Table 1 it follows that for all three 1 : 2 complexes *G. cingulata* is more sensitive than *A. niger*.

The fact that *G. cingulata* is inhibited by copper dimethyldithiocarbamate suggested that for this mould the inhibition pattern for sodium dimethyldithiocarbamate might be the same as for oxine and pyridine-N-oxide-2-thiol. The experimental results summarized in Table 2 lend support to this hypothesis. Moreover, from the known stability constants[3] and the solubility[2] of copper dimethylthiocarbamate, it is easy to calculate, the amounts of the 1 : 1 and 1 : 2 complexes present in each instance. The results were the same as those obtained earlier[1] with *A. niger* for 8-hydroxyquinoline and pyridine-N-

Table 1. SOLUBILITY AND TOXICITY OF THE 1 : 2 COMPLEXES OF COPPER

	Solubility in water (p.p.m.)	Minimum inhibiting conc. (p.p.m.)	
		A. niger	*G. cingulata*
$CuDDC_2$	0·01	no inhibition	0·05
$Cuox_2$	1	0·1	0·02–0·05
$CuPTO_2$	0·2	0·2	0·1

Table 2. EFFECT OF ADDITION OF COPPER SULPHATE ON GROWTH INHIBITION OF *Glomerella cingulata* BY SODIUM DIMETHYLDITHIOCARBAMATE, OXINE SULPHATE AND PYRIDINE-N-OXIDE-2-THIOL

$CuSO_4.5H_2O$ (p.p.m.)	Minimum inhibiting conc. (p.p.m.)		
	NaDDC	Oxine sulphate	PTO
0*	0·1	0·02	0·5
0·03	0·05	0·01–0·02	0·1
0·1	0·1	0·02	0·2
0·3	0·1	0·02	0·5
1	0·2	0·05	0·5
3	0·2	0·1	0·5

* Copper content not exceeding the equivalent of 0·01 p.p.m. $CuSO_4.5H_2O$.

Table 3. EFFECT OF THE ADDITION OF COPPER SULPHATE ON GROWTH INHIBITION OF *Glomerella cingulata* BY SODIUM DIETHYLDITHIOCARBAMATE (SHAKE CULTURE)

$CuSO_4.5H_2O$ (p.p.m.)	Sodium diethyldithiocarbamate (p.p.m.) 0	0·1	0·2	0·5	1	2	5	10	20	50
0*	+	±	±	+	+	+	+	±	−	−
0·1	+	+	±	±	+	+	+	+	−	−
0·3	+	+	−	−	+	+	+	+	−	−
1	+	+	−	−	−	−	±	±	±	−
10	+	+	−	−	−	−	−	−	±	−

* Copper content not exceeding the equivalent of 0·01 p.p.m. of $CuSO_4.5H_2O$.

oxide-2-thiol, namely, the toxicity is determined by the concentration of dissolved 1 : 2 complex, provided that an excess of copper is present in the medium in order that the 1 : 1 complex can be formed as well.

When no copper is added, toxicity is still rather high. This may be due to traces still present in the medium. When, however, all copper is bound by addition of 0·3–1 p.p.m. of sodium dibutyldithiocarbamate—a non-toxic agent with stronger chelating properties than the dimethyl compound, 8-hydroxyquinoline or pyridine-N-oxide-2-thiol—the minimal toxic concentrations of these compounds are 20, 5 and 5 p.p.m. respectively. These figures were not lowered by the addition of even fairly large amounts of ferrous sulphate (10–100 p.p.m.). Thus we must conclude that in contrast to the work of Albert and co-workers[4] with bacteria, the iron complexes are not toxic for moulds, as has also been found for 8-hydroxyquinoline by Anderson and Swaby[5].

We have also found that the fungitoxic action of homologues of sodium dimethyldithiocarbamate is determined in a similar way by the solubility of their 1 : 2 complexes with copper and the sensitivity of the test mould. For *G. cingulata* the inhibition pattern of sodium diethyldithiocarbamate (Table 3) is different from that of the dimethyl compound, but equals it for *A. niger*. This is easily understood from the finding that the solubility of the 1 : 2 complex of copper and diethyldithiocarbamate is far less than that of copper dimethyldithiocarbamate, namely, about 0·002 p.p.m. [2]. While the latter is still sufficiently soluble to inhibit *G. cingulata*, the former is not. Consequently, if sufficient copper is added to the medium, we find a zone of inversion growth (1 : 2 complex) and, at lower sodium diethyldithiocarbamate concentrations, a first zone of inhibition (1 : 1 complex). A second zone of inhibition is caused by the free dithiocarbamate (50 p.p.m.), as is the case with dimethyldithiocarbamate.

Thus a difference in toxicity of the 1 : 2 complexes of the methyl and ethyl compounds is found with *G. cingulata*. A difference in the toxic effect of the 1 : 1 complexes can be clearly seen from experiments with *A. niger*. Whereas sodium dimethyldithiocarbamate always shows a distinct first zone of inhibition in the presence of 10 p.p.m. copper sulphate due to formation of the 1 : 1 complex, no inhibition is seen when the diethyl compound is used instead.

This difference does not necessarily point to the diethyl 1 : 1 complex being less active as compared with the dimethyl 1 : 1 complex, for it is clear that a decrease in solubility of the 1 : 2 complex will cause a lower concentration of 1 : 1 complex in solutions of comparable composition.

When the dipropyl derivative is used, the amount of 1 : 1 complex present is much less again than with the diethyl compound. With *G. cingu*
complex causes only some incomplete
0·5–10 p.p.m. of sodium dimethyldit
when 10 p.p.m. of copper sulphate is
medium. The free dithiocarbamate its
be harmless, even at 200 p.p.m. Wit
derivative there is no inhibition up to

In conclusion, we may say that in the
range below 50 p.p.m. the inhibition p
dithiocarbamates is determined by the
the 1 : 2 complex with copper, and t
of the mould.

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Chromatography of Thiol Con

THE extreme ease of oxidation of th
has hindered the chromatographic s
mercaptans. Hanes, Hird and Isherwo
this difficulty by combining the thio
N-ethyl maleimide before chromatogr
tion. Cysteine and glutathione were
this way and detected by spraying t
papers with ninhydrin. This spray i
for mercaptans, however, and Price a
expanded the technique by condensing t
with N-(4-hydroxy-1-naphthyl) *isoma*
after chromatographic separation, d
naphthyl derivative by spraying with
di-*o*-anisidine.

The preparation of N-(4-hydroxy-1-
maleimide by the method of Tsou,
Seligman[3] is a two-step procedure, and
that the overall yield in the synthesis wa
a more readily available thiol-condensi
was sought.

The most promising compound of th
mercuric chloride. The formation o
complex with the thiol group prote
oxidation during the chromatographi
Furthermore, the introduction of a
into the compound made the detection
relatively easy, since the organo-mercu
reacted with alkaline dithizone (diph
azone).

Between 2 and 3 gm. of plant materi
in a mortar at room temperature w
of the mercuric chloride reagent (0·1 per
chloride in 40 per cent ethanol and buff
with *M*/5 acetate buffer). Buffering o
was necessary to obtain consistent res
subsequent chromatography. The inso
centrifuged away, the clear filtrate was
dryness *in vacuo*, and the residue was d
minimum quantity of 40 per cent ethan

tography. Excess mercuric chloride in the extracting solvent was essential to ensure complete protection of the thiol group from oxidation. After applying the solution to the Whatman No. 4 chromatography paper, the papers were developed in the descending direction using *tert*-butanol/acetic acid/water (4:1:1 v/v) solvent. Alkaline solvents were found to be completely unsatisfactory. Developing the papers in the butanol solvent for 18 hr. at 25° C. resulted in an identifiable separation of cysteine and glutathione, the cysteine having the greater R_F value.

Detection of the organo-mercuric compounds was achieved by spraying the paper with a solution of dithizone (0·03 per cent) in 0·1 *N* ammonium hydroxide followed by gentle warming. The compounds appeared as discrete salmon-pink spots after drying. This colour was stable only for a day or two in the light but for up to three months in the dark. 10 μgm. glutathione was detectable by this procedure.

The reaction between the thiol group and mercuric chloride appears to be partially dependent on the overall structure of the molecule. Neither *o*-thiobenzoic acid nor 2-thio-ethanol react under the conditions specified, but 2-thio-succinic acid, cysteine, cysteic acid and glutathione react readily. This suggests that the position in the carboxyl group in the molecule is also important in the formation of the complex.

Using this technique the presence of mercaptans other than glutathione and cysteine has been detected in dormant plant seeds. Further details of these results will be published later.

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Micro-electrophoresis

I should like to correct the reference to a publication from our laboratory[1] which appears in a recent article[2] entitled "An Apparatus for Micro-electrophoresis of Small Particles". In Table 1 of that article, a value of 1·31 ± 0·02 μ/sec./V./cm. is quoted as the electrophoretic mobility of human erythrocytes obtained with our apparatus. In our paper we stated: "The cell was calibrated using a suspension of human red blood cells, the mobility of which in *M*/15 phosphate buffer solution at *p*H 7·35 is 1·31 ± 0·02 microns/sec./V./cm.". This is the value obtained by Abramson[3] in an extensive study of the mobilities of mammalian blood cells.

Using the rectangular cells, constructed by fusing two optical flats a distance 0·5 mm. apart, it has so far been impossible to measure accurately the cross-sectional area (A) of the cell[4,5]. This is necessary for any absolute determination of mobility values, since the field strength (X) is determined from the equation $X = I/kA$, where I is the current in amperes and k the specific conductance of the dispersion. The cross-sectional area of rectangular cells constructed by cementing glass slides[6] can be measured directly, since the sides are square. The use of such cells has, however, been criticized on the grounds that the use of cement makes cleaning difficult and the unevenness of the surface interferes with the hydrodynamic behaviour of the liquid.

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We apologize to Dr. A. M. James for having misinterpreted the text of the paper by D. E. E. Loveday and him, with reference to the mobility of human erythrocytes in phosphate buffer at a *p*H of 7·4. We were under the impression that this was an actual experimental value.

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Effect of Hydrocortisone on Mitochondrial Membrane Permeability

Hydrocortisone has been found to inhibit severely oxidative metabolism *in vitro* by normal rat liver mitochondria. Concentrations of 5×10^{-4} *M* and greater inhibit the oxidation of octanoate, L-glutamate and all tricarboxylic acid cycle intermediates except succinate. Similar patterns of inhibition have been reported for other steroids[1-6].

The hydrocortisone used in this study was a purified sample free from metallic contamination. The steroid was dissolved in a minimal volume of re-distilled ethanol and diluted with water to the required concentration. Ethanol controls were included in each experiment.

Failure to inhibit succinate alone of the tricarboxylic acid substrate oxidations indicated that the mechanism of inhibition might involve pyridine nucleotides which are not present in the succinoxidase system. Reversal of the inhibitions could be achieved by addition of the appropriate coenzyme, nicotinamide and reduced glutathione, to the oxidizing system. This suggested either that hydrocortisone interfered with the function of the respiratory co-factors by competition, inactivation or complex formation or that the steroid acted directly on the mitochondrial membrane. Increased permeability of the mitochondrial membranes could lead to the inactivation of pyridine nucleotide-dependent dehydrogenases by loss of the soluble co-factors. 'Ageing' of enzyme preparations has this effect, as has the hepato-toxin carbon tetrachloride[7,8].

Evidence has been presented that steroids can in fact complex with nucleotides[9,10]. However, the present study shows that complex formation is not the inhibitory mechanism.

The activity of pyridine nucleotide-dependent enzymes may be followed spectrophotometrically by measuring the rate of reduction of the nucleotide, which in the reduced state absorbs light strongly at 340 mμ. The rate of substrate oxidation and linked nucleotide reduction by intact mitochondria is proportional to the permeability of the mitochondrial membrane to the passage of nucleotide and substrate which are added externally. Permeability of the membrane may thus be measured by the rate of reduction of nucleotide.

Fig. 1 shows clearly that hydrocortisone greatly increases the rate of reduction of diphosphopyridine nucleotide by intact mitochondria oxidizing L-malate. The increased optical density is neither due to absorption by the steroid nor to reduction of diphosphopyridine nucleotide in a reaction involving hydrocortisone.

Elimination of the semipermeable membrane barriers by suspension of the mitochondria in water instead of 0·25 *M* sucrose abolishes the effect of hydrocortisone (Fig. 2). The steroid neither accelerates nor inhibits the reduction of diphosphopyridine nucleotide under these conditions.

Comparison of the rates of reduction of diphosphopyridine nucleotide in Figs. 1 and 2, with allowance for the addition of twice as much enzyme in Fig. 1, shows that hydrocortisone increases the permeability of mitochondrial membranes to the same extent as suspension of the particles in water. Semipermeability is abolished.

It is thus clearly established that inhibition of oxidative metabolism *in vitro* by hydrocortisone is secondary to the action of the steroid in increasing the permeability of mitochondrial membranes. Loss of selective permeability allows the soluble co-factors of respiration to be leached from the mitochondria, inactivating pyridine nucleotide-linked dehydrogenases unless the lost co-factors are added in excess to the oxidizing system.

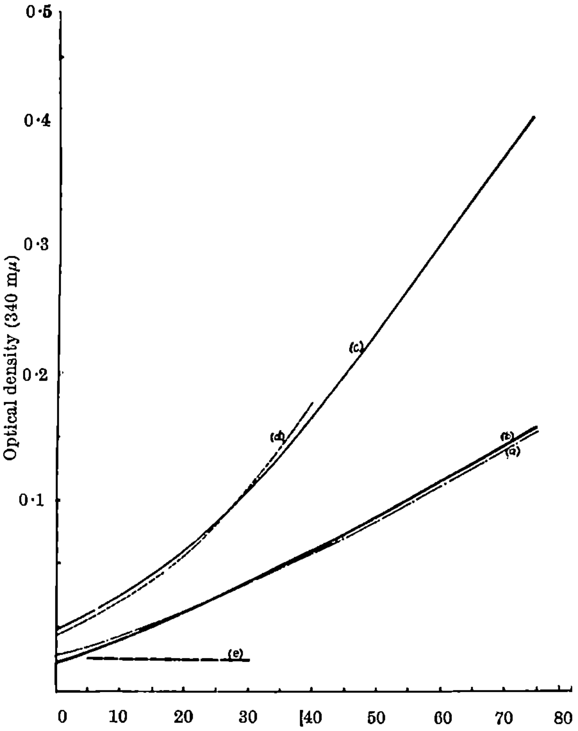

Fig. 1. Reduction of diphosphopyridine nucleotide by liver mitochondria in 0·25 *M* sucrose. (*a*) L-Malate, 0·01 *M*; (*b*) L-malate; 0·01 *M* and ethanol; (*c*) L-malate, 0·01 *M* and hydrocortisone, 0·001 *M*; (*d*) L-malate, 0·01 *M* and hydrocortisone, 0·0005 *M*; (*e*) hydrocortisone, 0·001 *M*. System: sodium–potassium phosphate buffer, *p*H 7·8, 0·033 *M*; potassium chloride, 0·025 *M*; magnesium sulphate, 0·0067 *M*; potassium cyanide, 0·0002 *M*; semicarbazide hydrochloride (neutralized), 0·17 *M*; diphosphopyridine nucleotide, 3 mgm.; enzyme, 50 μl. 1 per cent mitochondria (rat liver) in 0·25 *M* sucrose; water to final volume, 3 ml.; gas phase, air; temperature, 22° C.

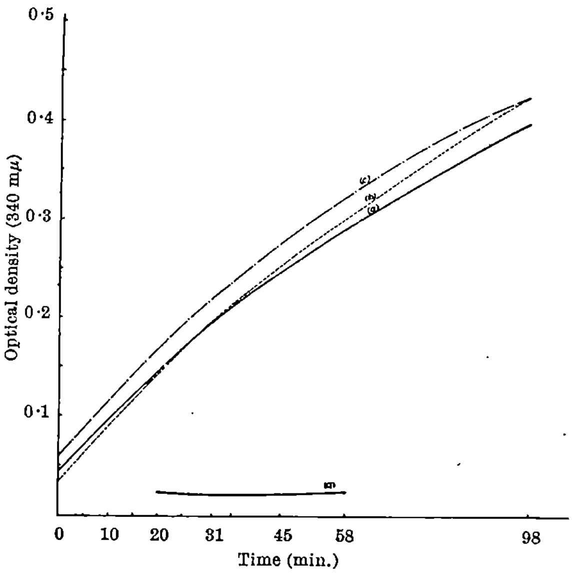

Fig. 2. Reduction of diphosphopyridine nucleotide by liver mitochondria in water. (*a*), (*b*) and (*c*), as Fig. 1; (*d*) hydrocortisone, 0·001 *M*. System: as Fig. 1, enzyme, 50 μl. 0·5 per cent mitochondria (rat liver) in water

This study is reported in detail and the significance discussed in a paper to be submitted to the *Biochemical Journal*.

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Effect of Ethylenediamine Tetraacetic Acid on the Enzyme System of Yeast Cells

THE peculiar property of amino-carboxylic acids like ethylenediamine tetraacetic acid of combining with metallic ions forming stable chelate complexes is now established, and has led to the varied uses of this acid in different industries, such as textiles, paper, leather, etc.[1,2]. Under a programme of investigation of the possible use of ethylenediamine tetraacetic acid in the sugar industry, it has been found that the sugar salt complexes responsible for the formation of molasses, and for the loss of appreciable amounts of sucrose in the sugar manufacturing process, could be broken by this acid, releasing the sugar molecules into the free condition; this led to a higher recovery of sugar[3]. During a series of experiments to investigate the possible use of ethylenediamine tetraacetic

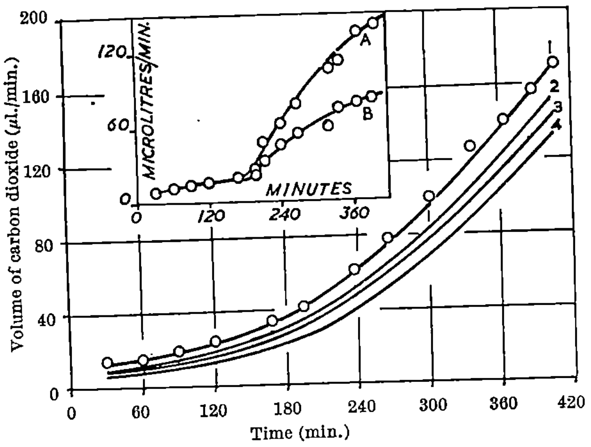

Fig. 1. Time-variation of the rate of evolution of carbon dioxide in the synthetic medium inoculated with yeast cells treated and untreated with ethylenediamine tetraacetic acid. Curves: (1) Yeast cells untreated; (2) treated with 1 per cent ethylenediamine tetraacetic acid for 4 hr.; (3) for 10 hr.; and (4) for 14 hr.

Inset: Curves refer to yeast cells treated with (*A*) 2·5 per cent and (*B*) 5 per cent ethylenediamine tetraacetic acid for 10 hr.

acid for enhancing the yield in the alcohol industry, a few interesting results have been obtained on the effect of the acid on the enzyme system of yeast cells (*Saccharomyces cerevisiae*).

Different samples of molasses obtained from the factories were diluted to 20° Brix; a portion (*A*) of the solution was mixed with the desired quantity (usually 0·25 per cent) of ethylenediamine tetraacetic acid; and the other (*B*) was treated as blank. *A* and *B* were inoculated with yeast and fermented at 30·0 ± 0·1° C. for 72 hr. The amount of alcohol produced, carbon dioxide evolved and yeast formed were estimated by the usual methods. The reducing matter and sucrose content before and after inversion were determined by Somogyi's method[4] which was found by initial experimentation not to be affected by the presence of ethylenediamine tetraacetic acid[5]. Similar experiments were carried out with synthetic media prepared according to White and Munns[6]. In accord with earlier observations[3,5], increased reducing matter and sucrose content were detected in *A*, that is, in the molasses samples and the synthetic media treated with the acid. It is interesting to note that the alcohol formed, carbon dioxide evolved and the yeast produced are markedly less in *A* than in *B*. Thus in one series of experiments, these were respectively 2·23, 6·02, 1·29 gm. in *B* and 2·16, 5·6 and 1·27 in *A*. This difference noted in *A* and *B* is much beyond the experimental accuracy of the methods of analysis. Remarkably enough the amount of sugar consumed during fermentation by yeast in *A* was 7·56 gm. while in *B* it was 6·5 gm. These results indicate that in samples treated with ethylenediamine tetraacetic acid the yeast, while consuming more sugar, gives less ethyl alcohol and carbon dioxide, and suggest that the yeast cells are apparently affected by the acid. This was substantiated by the experiments in which the blank samples of synthetic media *B* were inoculated by yeast which was pretreated with ethylenediamine tetraacetic acid as follows. Well washed yeast cells were suspended in solutions of different concentrations of the acid (in acetate buffer) for varied time-intervals at 5·0° C. and then centrifuged and washed thoroughly. The fermentation was followed up by using Warburg's respirometer. Fig. 1 gives a typical set of results obtained with synthetic media. It may be noted that the amount of carbon dioxide produced decreased markedly with the samples of yeast which were immersed in ethylenediamine tetraacetic acid solution for some time (inset Fig. 1). This is contrary to the favourable effect of the acid noted in the succinic dehydrogenase cytochrome system[7], adenosine triphosphatase[7], papain[8], etc.

Our thanks are due to Prof. S. N. Gundu Rao, director, for his interest and to Dr. N. A. Ramaiah, physical chemist, National Sugar Institute, for helpful discussions.

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A Plate Method for estimating the Numbers of Phosphate-dissolving and Acid-producing Bacteria in Soil

In the past, the preparation of plates for detecting phosphate-dissolving bacteria in soil has involved precipitation of the insoluble phosphate in the medium[1-3]. This method is not very suitable for use with the dilution-plate counting technique. For this purpose we have adapted and extended the suggestion of Johnson[4] in which finely divided dicalcium phosphate is incorporated in agar medium. Other forms of insoluble phosphates can also be used as well as insoluble carbonates. We have used calcium carbonate in this connexion for detecting and estimating acid-producing organisms in soil. Stock suspensions of the insoluble substances are prepared by grinding them in a ball-mill in the presence of gum arabic. The latter is necessary to prevent clumping of the finely divided substances during autoclaving.

Stock suspensions of dicalcium phosphate and calcium carbonate are made up at 2·5 per cent (w/v) and 1·5 per cent (w/v) respectively in 0·5 per cent (w/v) gum arabic. After grinding, they are adjusted to *p*H 8·4 before autoclaving and when afterwards added to molten agar medium the suspensions give uniform plates of a satisfactory and similar opacity. For preparation of the plates 1 ml. of the required suspension is added aseptically to 9 ml. of medium held at 45°. For soil counts we have used a modification of Bunt and Rovira's medium[5], containing 0·5 per cent glucose, in which the diammonium hydrogen phosphate is replaced by 0·05 per cent ammonium sulphate and the *p*H adjusted to 6·8. After thoroughly mixing, by hand rolling, the medium containing the dispersed insoluble compound is poured into Petri dishes already containing the 1-ml. aliquot from the appropriate soil dilution flasks. The insoluble compounds in the final plates when examined by X-ray analysis are found to be chemically unchanged. The plates are incubated at 25° C. for 14 days and the total number of colonies

Table 1

Soil	Dicalcium phosphate dissolving organisms (per cent)	Calcium carbonate dissolving organisms (per cent)
Garden	17·9	48·2
Field	16·2	44·7

and those showing halo production counted. Table 1 gives the results obtained from a field and garden soil.

It can be seen that there is a much higher percentage of acid-producing than phosphate-dissolving organisms, showing that not all acid producers can dissolve insoluble phosphates in soil. Increasing the calcium carbonate to the same concentration as the dicalcium phosphate in the plates (0·25 per cent) did not affect this result. Other forms of insoluble inorganic phosphates tried included freshly precipitated hydroxy-apatite as prepared by Sperber[3]. This did not give as high counts as were obtained with dicalcium phosphate.

It should be mentioned that the technique probably gives an under-estimate of the total numbers of phosphate-dissolving organisms in soil as it is too insensitive to detect those dissolving very small amounts. However, when a comparative study of a large number of soils is required the method has been found to be very convenient. Full details of the results obtained with it and other work on bacteria dissolving phosphate will be published elsewhere.

We are grateful to Mr. W. A. Mitchell of this Institute for carrying out the X-ray analyses.

One of us (H. A. L.) wishes to make acknowledgment to the South African Department of Agriculture and the South African Wheat Industry Control Board for financial support.

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Aerobic Transformation of Cysteine to Sulphate in Soil

MUCH of the sulphur in soils under pasture in humid and semi-arid regions is in the organic form[1,2], and plants are largely dependent on the conversion of this sulphur to sulphate for their nutrition. At the present time little information is available regarding this transformation in soil. Studies conducted with pure cultures of various soil micro-organisms suggest that, under aerobic conditions, sulphate, sulphur, or hydrogen sulphide may be end-products in the decomposition of organic sulphur compounds. Excellent reviews of this work have been published[3,4].

In order to gain information of the reaction sequence carried out by the mixed flora of a typical 'humid' soil, the oxidation of cysteine was observed using a perfusion unit of the type described by Lees and Quastel[5].

A 0·01 *M* solution of cysteine was perfused through 30 gm. of soil held in the perfusion unit, and samples were removed for qualitative paper chromatographic analysis at two-hourly intervals over a period of three days. Oxidation of the cysteine during chr
was prevented by the use of N-ethyl-ma
amount of cysteine and cystine in the p
determined quantitatively by the meth
by Snell and Snell[6].

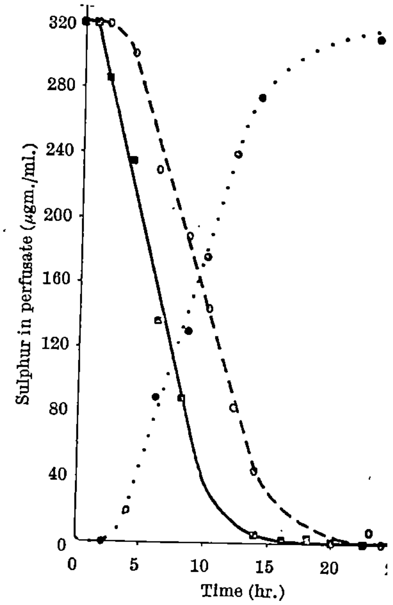

Fig. 1. Conversion of cysteine to cystine in
– – –, Disappearance of cysteine sulphur; . . . .,
production; ——, disappearance of cysteine
solution 0·01 *M* with respect to azid

Cystine and cystine disulphoxide we
identified on the chromatograms. Tau
detected. The identity of cystine
was established by co-chromatography c
the perfusate with the authentic chemical
of solvent systems.

The conversion of cysteine to cystin
rapidly (Fig. 1). In the presence of az
version was somewhat more rapid than
was not added. The acceleration of this re
presence of azide is not explained, but t
it proceeds under these conditions sugge
non-biological. Cysteine did not appea
formed from cystine, as it could not be
the perfusate by paper chromatograph
first twenty-four hours.

30 gm. of soil were enriched with mic
carrying out the oxidation of cysteine
by perfusion with 200 ml. of 0·01 *M* cyst
sulphate production was plotted agai
curve with the typical lag phase of
organisms was obtained (Fig. 2*A*). The
then freed from sulphate by washing w
water, and solutions of possible intermedi
fused through the enriched soil, and su
duction again measured.

When cystine and cystine disulphoxid
fused through an enriched soil, their su
duction rate curves did not show the
exhibited by cysteine when it was perfus
fresh soil (Fig. 2). Again, when solutio
compounds were perfused through fres
sulphate production rate curves were sim
obtained for cysteine (Fig. 2*A*). It appea
population present in the enriched soil v
of oxidizing cystine and cystine disul
sulphate, and that these two compounds

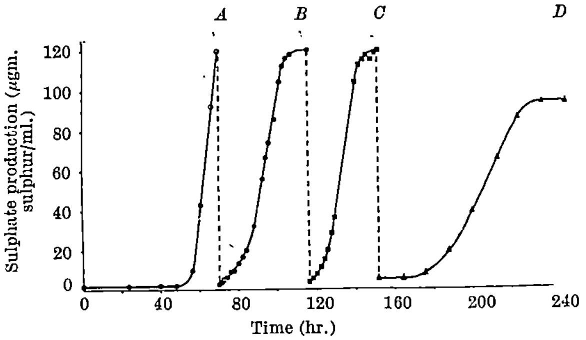

Fig. 2. *A*, 0·01 *M* cysteine solution perfused through 30 gm. fresh soil; *B*, soil from *A* washed free from sulphate then re-perfused with 0·002 *M* cystine hydrochloride solution; *C*, soil from *B* freed from sulphate then perfused with 0·002 *M* cystine disulphoxide hydrochloride solution; *D*, soil from *C* freed from sulphate then perfused with 0·004 *M* taurine solution

intermediates in the transformation of cysteine to sulphate.

Taurine, however, which could not be detected in the perfusate by paper chromatography, was not immediately oxidized to sulphate when perfused through an enriched soil (Fig. 2*D*).

The results obtained here indicate that the transformation of cysteine to sulphate in soil follows the sequence: cysteine→cystine→cystine disulphoxide→ cysteine sulphinic acid→sulphate. Although cysteine sulphenic acid has been suggested as an intermediate in the production of sulphate in animal metabolism[7-9], in our system, if it is formed, it would be derived from cystine disulphoxide and not directly from cysteine.

Part of the work reported here was carried out at the Kearney Foundation of Soil Science, University of California, Berkeley, during the tenure of a Commonwealth Scientific and Industrial Research Organization (Australia) Studentship.

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Effect of Gibberellic Acid on the Nodulation of White Clover (*Trifolium repens* L.)

In a recent communication, Thurber, Douglas and Galston[1] reported that spraying of dwarf beans (*Phaseolus vulgaris*) with potassium gibberellate greatly decreased nodulation and they indicated the need for caution in the application of gibberellins to leguminous plants. Probably the most widely used legume in Britain is white clover (*Trifolium repens*), and it is therefore of interest to note the effect of gibberellic acid on the nodulation of this plant.

Table 1

	No. of nodules per plant
Control	11
Gibberellic acid incorporated in agar and added gibberellic acid	11
Added gibberellic acid only	10

Experiments were carried out in both agar and in soil culture. The nitrogen-free agar culture technique was that previously described[2], there being one plant per tube. Ten tubes were set up with 20 p.p.m. gibberellic acid incorporated in the agar-rooting medium and a further 1 ml. of 20 p.p.m. solution added when the seedlings were transplanted; ten more tubes containing the ordinary agar-rooting medium had 1 ml. of 20 p.p.m. gibberellic acid solution added at transplanting; and there were ten control tubes with no gibberellic acid. The plants were allowed to grow for ten weeks in a cool greenhouse and then harvested. That the gibberellic acid was active was shown by the typical effects on the plant, namely, marked elongation of the hypocotyl and leaf petiole.

In the soil experiment, the clover plants were grown from seed in 3½-in. pots, each pot containing 230 gm. of John Innes compost. Each pot of soil was inoculated with 1·25 ml. of a suspension of *Rhizobium trifolii* (strain 157) containing approximately 260 million bacteria per ml. When the plants had reached the two-leaf stage they were thinned to eight plants per pot. At the three-leaf stage 15 pots of plants were sprayed to dripping point with a solution of 50 p.p.m. gibberellic acid containing 0·1 per cent 'Tween 80' as a spreader. A further 15 pots of plants were sprayed with water containing 0·1 per cent 'Tween 80' as controls. The treatments were repeated ten days later. The plants were harvested sixteen days after the last treatment, by which time the control plants had reached the 10–12 leaf stage. The treated plants were showing a marked increase in petiole length and in leaf area, but a reduction in leaf number to 5 or 6 leaves per plant. The nodules were counted and their dry weights determined. Each reading is the mean of 120 plants.

All plants were well nodulated and the nodules were large and pink in colour, indicating that they were effective. One point of interest, not related to nodulation, was that of a further 30 pots of treated plants left for observation, 15 were showing inflorescence formation some 50 days after treatment and only 2 out of 30 untreated were at a similar stage of development.

The effect of gibberellic acid on the growth of the nodule-forming organism was also tested using a turbidimetric method and growing the organism in wheat extract[3] and sauerkraut[4] media. The concentrations of gibberellic acid used were 1, 25, 50, 100 and 1,000 p.p.m. and readings were taken daily for 14 days. None of the concentrations used had any adverse effect on the growth of *Rhizobium trifolii* (strain 157).

Table 2

	No. of nodules per plant	Dry weight of nodules per plant (mgm.)
Plants sprayed with gibberellic acid	20	3
Plants sprayed with water	21	3

It would appear, then, that gibberellic acid, when used in the quantities indicated, has no adverse effect on the nodulation of white clover either in aseptic agar or in soil culture or on the growth of the nodule-forming organism.

Thanks are due to J. Anderson and C. McCombie for technical assistance and to Plant Protection, Ltd., which supplied the gibberellic acid for experimental purposes.

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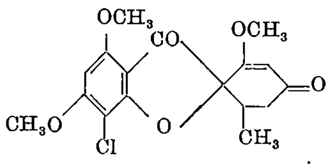
Some Cytological Effects of Griseofulvin

Griseofulvin is a fermentation product of three species of *Penicillium*—*P. patulum*, *P. griseofulvin*, and *P. janczewskii*—which, in very low concentration, suppresses growth and induces striking changes in the hyphæ of a number of fungal species[1].



Griseofulvin

In laboratory mammals the lethal dose is high; Wistar rats of either sex tolerate a daily dose of 2 gm./kgm. given intraperitoneally in aqueous suspension for several days. When the tissues from rats dosed at this level for four days and killed on the fifth were examined histologically, we found the seminal epithelium to be severely damaged and in many places completely necrotic (Fig. 1). The intestinal epithelium also showed abnormalities, but these were less marked. The median lethal dose to rats by intravenous injection is of the order of 400 mgm./kgm. and we have found that some 6 hr. after a single intravenous dose of griseofulvin (100 or 200 mgm./kgm.) a striking arrest of mitosis in metaphase is evident in sites of mitotic activity in the rat. It is very marked in the bone marrow (Fig. 2*a*) and intestine (Fig. 2*b*) and, in rats bearing transplanted tumour (Walker carcinoma 256 or a lymphosarcoma), in the growing tumour tissue. Cells arrested in metaphase show, in varying degree, disorientation and scattering of the chromosomes through the cytoplasm (Fig. 3) such as is seen after colchicine, and in some instances beading or pyknosis of the chromosomes. Interference with mitosis in the bone marrow is reflected in a profound fall in the numbers of circulating red and white blood cells. In rats 24 hr. after this single dose the bone marrow is congested and contains little hæmopoietic tissue; mitotic figures are infrequent but mostly appear normal, while pyknotic and degenerate nuclei are still occasionally seen. In spite of these profound effects the rats appear little affected in general condition and at no stage show very obvious signs of intoxication. Recovery in most of the affected tissues proceeds rapidly after 24 hr., although the effects of interference with spermatogenesis are still discernible in the testes at least 10 days after the single dose.

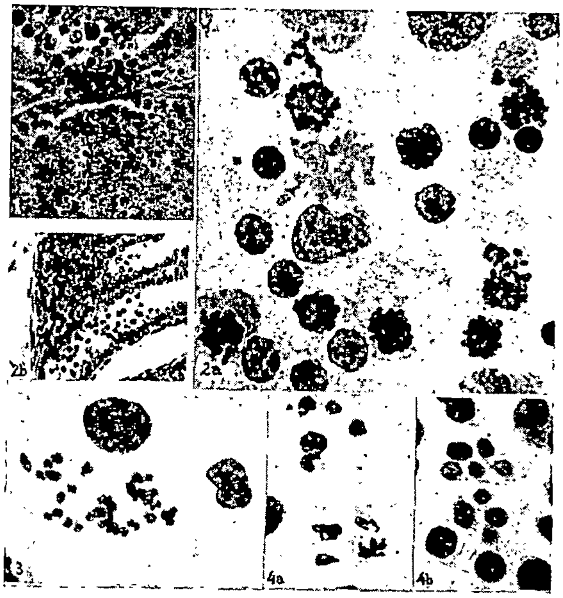


Fig. 1. Section of seminiferous tubules of a rat given griseofulvin intraperitoneally in aqueous suspension, 2 gm./kgm. daily for four consecutive days and killed on the fifth day. Hæmatoxylin and eosin. (×170)

Fig. 2. Tissues of a rat 6 hr. after a single intravenous dose of griseofulvin, 200 mgm./kgm., showing arrest of mitosis in metaphase. *a*, Bone marrow, squash preparation, Feulgen stain (× 600); *b*, intestinal crypts, section, Feulgen. (× 85)

Fig. 3. Bone marrow of a rat after a single intravenous dose of griseofulvin, 200 mgm./kgm., showing at 5 hr. scattering of metaphase chromosomes. Squash preparations, Feulgen stain. (× 600)

Fig. 4. Root-tips of *Vicia faba* after continuous exposure to supersaturated aqueous griseofulvin for *a*, 4 hr., and *b*, 16 hr. Feulgen stain, squash preparations. (× 200)

The true solubility of griseofulvin in water at room temperature is about 10 µgm./ml. Supersaturated solutions containing 20–40 µgm./ml. can be prepared by dissolving in water boiling under reflux (1 hr.), cooling and filtering. Growing roots of *Vicia faba* were immersed in such solutions for varying periods and their tips, fixed either immediately or after varying periods of recovery in tap water, were studied cytologically. Supersaturated solutions of griseofulvin produce some delay in mitosis at metaphase in bean roots within ½–1 hr. of their immersion, but a more striking feature of its action is the induction of multipolar mitosis. In many cells, after separation of the chromatids, the total complement of chromosomes segregates into irregular groups, up to five in number, which are then reconstructed as nuclei of varying size within the original cell (Fig. 4*a*). Cell-cleavage follows in some instances resulting in small mononuclear cells of variable size (Fig. 4*b*). In 'recovery' experiments in which the root-tips were finally exposed to colchicine (0·05 per cent aqueous for 4 hr.) before fixation a small number of tetraploid cells was seen, but under the conditions of our experiments the agent gives rise to fewer polyploid nuclei than would be expected with colchicine itself.

The effects of griseofulvin upon mitosis in some respects resemble those of colchicine; but in rats, at least, it seems much less generally toxic in doses required to produce equivalent metaphase arrest.

the belief that this agent may prove useful to workers in the field of cytology and genetics.

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[1] Brian, P. W., *Ann. Bot.*, 13, 59 (1949).

Gibberellic Acid and the Physiological Genetics of Flowering in Peas

IN peas (*Pisum sativum*) Barber[1] has shown that the *Sn* gene which is dominant for a delay in flowering to a higher node has at least four other pleiotropic effects. The gene induces competence to respond to photoperiod and vernalization; it delays the formation of the first leaf with more than two leaflets; and it causes a small reduction in internode length. The reduction in length is only about 10 per cent of that caused by segregation at the *Le* locus. These effects were investigated by appropriate crosses among the four commercial varieties: Telephone (late flowering, tall: *Sn Le*), Greenfeast (late, dwarf: *Sn le*), Alaska (early, tall: *sn Le*) and Massey (early, dwarf: *sn le*). The crosses have also given some evidence that segregation at the *Le* locus may modify the action of *Sn*, *Le Sn* plants flowering about 0·5 node later than *le Sn* plants in appropriate F_2s. The modifying effect of *Le* is 5–10 per cent of the effect of *Sn*. Segregation at the *Le* locus appears to have no effect on an *sn* background.

Brian and Hemming[2] have shown that segregation at the *Le* locus affects some aspect of the metabolism of the gibberellins. In view of the over-lapping pleiotropic effects of segregation at the *Le* and *Sn* loci, we have made an investigation of the effect of gibberellic acid on flowering in the four varieties. The varieties were combined factorially with two photoperiods (18 hr. and 9 hr.), two vernalization treatments (unvernalized and three weeks at 4° C.), and two gibberellic acid treatments (none and 1 μgm. applied to dry seed prior to germination).

The results for node of first initiated flower are given in Fig. 1. The reaction of the varieties to photoperiod and vernalization is as described by Barber[1], late (*Sn*) varieties flowering at a lower node in long days and when vernalized, while early varieties (*sn*) show no response to either environmental variable. The effect of gibberellic acid is to delay initiation of flowering in all varieties. The mean delay varies from about 0·5 node in Alaska to 1·7 node in Massey, giving a delay in time of about one to three days. Gibberellic acid usually causes considerable abortion of flower rudiments so that the delay in production of open flowers is variable and may be considerably longer than three days.

There is a statistically significant interaction between *Le* and gibberellic acid, the effect of the acid on flowering being less in the tall varieties. Brian[3] has shown similarly that the effect of gibberellic acid in controlling growth in length of stem is less in tall than in dwarf varieties. There are no highly significant gibberellic acid × *Sn* interactions. There is an apparently highly significant gibberellic acid × V interaction in long days. However, this interaction seems largely to be due to the behaviour of Massey, which has proved to be anomalous in this experiment. Further experiments to test in detail the behaviour of Massey to gibberellic acid have given no indication of any effect of vernalization and photoperiod on the delay in flowering induced by the gibberellic acid. These latter experiments included both higher total dose and doses applied after germination to plumule and leaves.

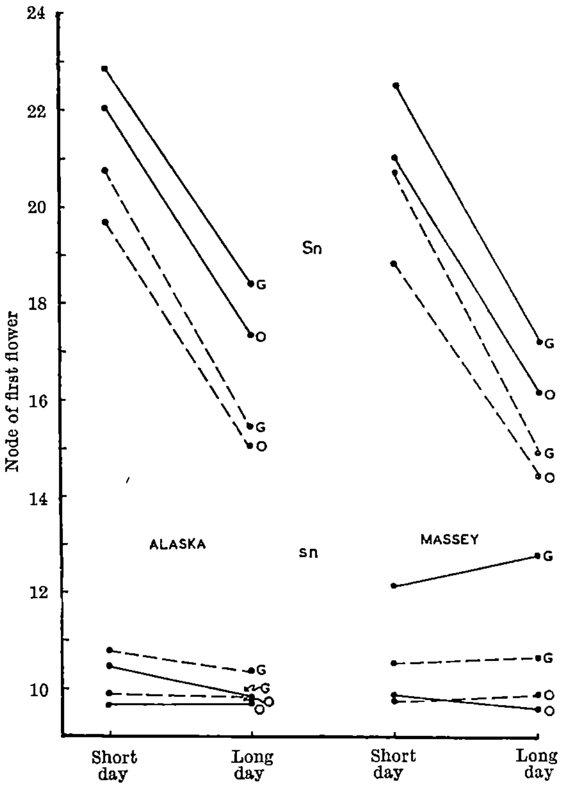

Fig. 1. Effects of gibberellic acid on node of initiation of flowers in four varieties of peas under different photoperiods (short-day, 9 hr.; long-day, 18 hr.) and vernalization treatments (unvernalized; vernalized by 3 weeks at 4° C.). ●– – –●, Vernalized; ●——●, unvernalized; *G*, treated with gibberellic acid; O, untreated

There is some evidence that in *Sn* plants gibberellic acid treatment followed by vernalization may increase the effect of photoperiod. This is in curious contrast to the behaviour of plants not treated with gibberellic acid, where Barber[1] has shown that prior vernalization reduces the photoperiodic response. However, for unknown reasons this competitive effect of vernalization on photoperiod is much weaker in the untreated plants in our experiments. Further experiments are planned to test the significance of these complex interactions.

In addition to the effect on flower-initiation, these experiments have shown that gibberellic acid, like the *Sn* gene, delays the production of leaves with more than two leaflets.

Barber and Paton[4,5] have suggested that the *Sn* gene in peas exerts its effect by producing a hormonal substance which delays the initiation of flowers. Barber[1] concluded that the production of the inhibitor is responsible for the competence of late varieties to respond to photoperiod and vernalization, the inhibitor being selectively destroyed during long days and at low temperatures. The fact that gibberellic acid certainly affects three of those characteristics pleiofirst flower, leaf type, and internode length) and possibly may alter the size of the photoperiodic effect under certain conditions, indicates that the *Sn* gene is probably working, like the *Le* gene, by way of some aspect of the gibberellic metabolism of the plant. It is clear that gibberellic acid is not, itself, the flower-inhibitor produced by the *Sn* gene. However, the production of the flower-inhibitor may be linked to gibberellin metabolism either by way of a common precursor or more indirectly by a reaction involving the production and utilization of the gibberellins.

We wish to thank Dr. P. W. Brian (Imperial Chemical Industries) for the gift of the gibberellic acid used in these experiments. One of us (I. C. M.) wishes to acknowledge the assistance of a research studentship of the C.S.I.R.O. and another (J. I. S.) held the I.C.I.A.N.Z. Research Fellowship of the University of Tasmania. The Rural Credits Division of the Commonwealth Bank of Australia has helped us by providing funds for technical assistance, apparatus and glasshouses.

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W. D. JACKSON
I. C. MURFET
J. I. SPRENT

University of Tasmania,
Hobart. Aug. 11.

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Effect of Trauma on Wool Growth

A RECENT communication[1] indicated that mechanical trauma such as cutting or scratching the rabbit skin was sufficient to cause a sudden stimulation of hair growth around the site of injury. This effect was observed most dramatically in the quiescent phase of the hair growth-cycle. Because hair replacement in the mouse, rat, and rabbit is discontinuous and occurs in cyclical waves of active growth, Ghadially[1] suggested that the mechanical damage caused quiescent skin to become active and as a result stimulated hair growth. In the case of guinea pigs and man, he reported no gross hair growth-cycle but each hair showed an independent cycle of growth and quiescence. However, he did not indicate whether the hair types from the latter groups would exhibit stimulated growth from trauma.

In our studies on the growth of wool as related to intake of protein, wool samples were collected monthly from tattooed areas on the right shoulder. During the course of sampling we have observed that simple mechanical trauma, as judged by 'bumps' or elevations on the skin, has resulted in a stimulation of growth of wool on the elevated areas. These elevations resulted from the sheep being bumped on the shoulder area as it entered an individual feeding pen. This phenomenon was not noted during subsequent sampling periods and consequently was considered to be of a temporary nature. Wool samples were collected from the elevated area (Sample 1) and from the surrounding area (Sample 2) and 50 fibres were measured for length and thickness. The results are shown in Table 1.

	Sample 1	Sample 2
Crimped length (mm.)	14·0	12·5
Decrimped length (mm.)	18·4 (±1·5)*	17·7 (±1·9)*
Ratio: decrimped length/crimped length	1·3	1·4
Fibre thickness (μ)	20·4 (±3·5)*	17·7 (±2·4)*

* Standard deviation

It is evident from these determinations that there was an increase in the average lengths ($P < 0{\cdot}05$) and thickness ($P < 0{\cdot}01$) of those fibres exposed to trauma when compared with those from the surrounding area. Ghadially[1] has indicated that mechanical damage caused quiescent skin to become active and as a result stimulated hair growth. In the case of sheep it was evident that growth of wool was stimulated although the fibre is a continuously growing filament and not subject to periods of quiescence[2]. Haddow *et al.*[3] and Haddow and Rudall[4] showed that there was a greater density of blood vessels in the skin of rats at the advancing edge of the zone of active hair growth. Durward and Rudall[5] also found that the blood vessel network around the follicle was most dense when the hairs were actively growing, but became reduced during the resting stage of the hair growth-cycle. Ferguson *et al.*[6] deduced that in sheep higher temperatures influenced growth of wool by causing vasodilation and a consequent increased flow of nutrients to the follicle. Ferguson[7] also showed that vasodilation caused by unilateral sympathectomy increased growth of wool on the side of the body in which the nerves had been cut. In view of this it is suggested that trauma, with its concomitant increase in blood supply to the site of injury, stimulated growth of wool.

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Experimental Farm,
Lethbridge, Alberta.
Sept. 3.

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Isolation and Pure Culture of *Monoblepharis*

ALTHOUGH the genus *Monoblepharis* has been known since 1871 and its species have been collected in many parts of the world[1], there has been no account of its isolation and growth in pure culture, so in 1957 pure culture studies were begun. The investigation is not yet complete, but one of the techniques developed is reported here in view of its possible interest to other mycologists.

The inoculum was derived from natural growths of *Monoblepharis* sp. on twigs of *Quercus robur* L.[1]. Hyphal tufts were teased out under a wide-field binocular microscope, and washed by transference to at least ten successive dishes of sterile distilled water. A small portion of one of these hyphal tufts was then transferred to a cavity slide containing a drop of sterile distilled water and the material observed at a higher magnification (× 500). Tips of hyphæ from a mycelium bearing sexual reproductive organs (by means of which species are identi-

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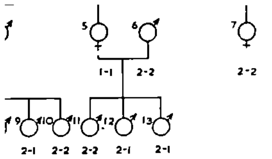

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FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, November 10

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. R. B. Braithwaite: "Identifications as the only Axioms for a Science".

ROYAL INSTITUTION, LIBRARY CIRCLE (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Captain J. L. Pritchard: "The First Centuries of Flight".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the Woolwich Polytechnic Scientific Society, at the Woolwich Polytechnic, London, S.E.18), at 7.30 p.m.—Dr. A. G. Davies: "The Stereochemistry of Some Reaction Mechanisms".

BRITISH PSYCHOLOGICAL SOCIETY (at Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Dr. H. Himmelweit: "The Relevance to Social and Child Psychology of a Study of the Effects of Television on Children".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Dr. Paul A. Siple: "South Pole Station".

Tuesday, November 11

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road, London, E.1), at 1.30 p.m.—Mr. Ritchie Calder: "H. G. Wells".*

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. H. S. W. Massey, F.R.S.: "Exploration of Space".*

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

INSTITUTION OF THE RUBBER INDUSTRY, LONDON SECTION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. C. H. Gregory: "Rubber Products for the Motor Industry". 7 p.m.—Mr. S. G. Fogg: "Natural Rubber Compounds for High Temperature Service".

UNIVERSITY OF LONDON (at the Imperial College of Science and Technology, London, S.W.7), at 5.30 p.m.—Prof. S. R. Sparkes: "Engineering Structures—Teaching and Research" (Inaugural Lecture).

INSTITUTION OF MECHANICAL ENGINEERS, AUTOMOBILE DIVISION (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. T. C. F. Stott: "Fatigue Testing of Vehicle Components".

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. W. B. Wright and Mr. W. Elland: "The Integrated Iron and Steel Works".

ROYAL AERONAUTICAL SOCIETY (in the Theatre, Park Lane House, 45 Park Lane, London, W.1), at 7 p.m.—Dr. J. Williams: "Boundary Layer Control to Produce High Lift at Low Speeds".

ROYAL AERONAUTICAL SOCIETY, GRADUATES' AND STUDENTS' SECTION (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Sir Gerard D'Erlanger: "The Air Transport Auxiliary".

Wednesday, November 12

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. W. S. McKerrow and Dr. C. J. Campbell: "The Lower Palæozoic Rocks of North-West Galway"; Dr. J. F. Evernden (University of California): "Potassium/Argon Dating of Tertiary and Pleistocene Rocks".

SOCIETY OF INSTRUMENT TECHNOLOGY, CONTROL SECTION (at Manson House, Portland Place, London, W.1), at 6 p.m.—Dr. P. Fellgett: "Some Applications of Control Technique in Astronomy".

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (joint meeting with the PLASTICS AND POLYMER GROUP, at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. H. G. Cole and Mrs. V. E. Rance: "Plastics and other Polymers as Sources of Corrosive Vapours"; Mr. A. C. Docherty and Mr. H. Hughes: "Plastics for Protection Against Corrosion".

Wednesday, November 12—Thursday, November 13

ROYAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 2.30 p.m. on Wednesday and 10 a.m. on Thursday—Discussion on "Space Research" opened by Prof. H. S. W. Massey, F.R.S.

Thursday, November 13

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. A. Maccoll: "Some Impressions of the Colleges in West Africa and the West Indies".*

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (at the Royal School of Mines, London, S.W.7), at 4 p.m.—Dr. J. M. Lock: "Cryotrons".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5 p.m.—Mr. C. B. Winsten: "Geometric Distributions in the Theory of Queues".

INSTITUTION OF MECHANICAL ENGINEERS, HYDRAULICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Flow—the Origin and Nature of Turbulence: Boundary-Layer Occurrences".

CHEMICAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 7.30 p.m.—Prof. Dr. K. Clusius: "Chemical and Technological Aspects of ^{15}N-Chemistry".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at Croydon Technical College, Fairfield, Croydon, Surrey), at 7.30 p.m.—Dr. G. B. Cook: "The Use of Radioisotopes in Industry and Medicine".

Friday, November 14

BIOCHEMICAL SOCIETY (at the National Institute of Medical Research, The Ridgeway, Mill Hill, London, N.W.7), at 2 p.m.—377th Meeting.

INSTITUTION OF MECHANICAL ENGINEERS (in conjunction with the STEAM GROUP, at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. T. Furman and Mr. H. Hampson: "Experimental Investigation into the Effects of Cross Flow with Condensation of Steam and Steam-Gas Mixtures on a Vertical Tube".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. G. G. Gouriet: "Colour Television—Progress During the Last Decade".

Friday, November 14—Saturday, November 15

BRITISH SOCIETY FOR IMMUNOLOGY (joint meeting with the BRITISH ASSOCIATION OF ALLERGISTS, at the Wellcome Building, Euston Road, London, N.W.1), at 2.30 p.m. Friday—Symposium on "Immunological Aspects of Allergic Disorders". Chairman: Dr. D. Blair Macaulay.

Saturday, November 15

BRITISH PSYCHOLOGICAL SOCIETY, EDUCATION SECTION (in conjunction with the ASSOCIATION FOR TEACHERS IN COLLEGES AND DEPARTMENTS OF EDUCATION, in the Assembly Hall, University of London Institute of Education, Malet Street, London, W.C.1), at 10 a.m.—Symposium on "Psychology in the Three-year Teacher-Training Course".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. R. Bassindale: "The Natural History of Ghana".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

JUNIOR LECTURER or LECTURER, and a LECTURER or SENIOR LECTURER IN THE DEPARTMENT OF BACTERIOLOGY—The Dean, Guy's Hospital Medical School, London, S.E.1 (November 14).

RESEARCH ASSISTANT, for work in the general field of photoconductance, absorption spectra and other electronic properties of ionic solids—Dr. F. C. Tomkins, Chemistry Department, Imperial College of Science and Technology, London, S.W.7 (November 15).

ASSISTANT LECTURER (with special qualifications in stratigraphy and/or palæontology) IN GEOLOGY—The Secretary, The University, Belfast (November 20).

ASSISTANT LECTURER (with special qualifications in applied mathematics) IN MATHEMATICS—The Registrar, The University, Manchester (November 22).

CARTOGRAPHIC DRAUGHTSMAN (able to compile and prepare maps for publication, and preferably geography graduate) IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University, Leeds 2 (November 24).

TEMPORARY LECTURER IN MEDICAL AND VETERINARY ENTOMOLOGY—The Secretary, The University, Edinburgh (November 29).

RESEARCH FELLOW IN PÆDIATRIC PHYSIOLOGY IN THE DEPARTMENT OF PHYSIOLOGY, for the study of problems relating to the physiology of infancy and childhood—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (November 30).

SENIOR LECTURER IN ANATOMY (GROSS ANATOMY) at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

SENIOR LECTURER IN BOTANY, and a LECTURER IN BOTANY—The Registrar, University of New England, Armidale, N.S.W., Australia, or The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 30).

LECTURER IN PHILOSOPHY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 8)

LECTURER (competent to lecture in economic geology and structural geology) IN GEOLOGY at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 15).

LECTURER (with an honours degree in mathematics) IN MATHEMATICS WITHIN THE DEPARTMENT OF EXTERNAL STUDIES, University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 15).

RALSTON PROFESSOR OF ZOOLOGY in the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 15).

READER IN AERONAUTICS at Imperial College—The Academic Registrar, University of London, Senate House, London, W.C.1 (December 15).

RESEARCH FELLOW (with a good knowledge of electronics) IN THE DEPARTMENT OF PHYSICS, University of New England, Armidale, N.S.W., Australia, to engage in a research programme on spark discharges in association with Prof. J. M. Somerville—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 18).

Professor of Forestry—The Registrar, University Registry, Oxford (December 24).

Chair of Botany—The Registrar, The University, Hull (December 31).

Chair of Philosophy in the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, December 31).

Reader or Senior Lecturer in Clinical Physiology at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 1).

Fisheries Officer (with a university degree in marine biology and suitable postgraduate experience) in the Department of Agriculture, Bahamas, to advise on fisheries conservation, introduce new fishing methods, and enforce the fisheries laws—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/27/04.

Plant Pathologist/Virologist (with a good honours degree in a biological science and postgraduate training or experience in plant virus work) at the West African Cocoa Research Institute, Sub-station Ibadan, Nigeria, to carry out research on plant pathological problems relating to cocoa—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD/197/200/017.

Research Assistant (chemistry graduate), to study anionic polymerization with emphasis on reaction mechanisms of stereospecific systems—The Head, National College of Rubber Technology, Northern Polytechnic, Holloway, London, N.7.

Research Assistant (male or female) in Biochemistry—The Medical Superintendent, Western General Hospital, Edinburgh 4.

Research Technician, to work on biochemical problems in a diabetic clinic and laboratory—The Personnel Officer, St. Thomas's Hospital, London, S.E.1.

Senior and Junior Physicist in the Physics Department—The Clerk to the Governors, St. Bartholomew's Hospital, London, E.C.1, marking envelope "Physicist".

Senior Lecturer in Electrical Power, a Lecturer in Electrical Circuits and Machines, and an Assistant Lecturer in Electrical Engineering—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The North Staffordshire Field Club. Transactions and Annual Report, 1956–1957. Pp. 118. (Vol. 91.) (Stoke-on-Trent: North Staffordshire Field Club, 1958.) 15*s*. [129

Library Association: North Western Group. Reference and Special Libraries Section. Occasional Papers, No. 1: Library Classification and the Field of Knowledge. By D. J. Foskett. Pp. 15. (London: Library Association, 1958.) 2*s*. 6*d*. [129

Wye College (University of London). Department of Hop Research Annual Report from 1st April, 1957, to 31st March, 1958. Pp. 159. 5*s*. Hop Research at Wye College in 1957. By H. S. Darling. Pp. 5. (Wye: Wye College, University of London, 1958.) [129

Library Association. Special Subject List No. 27: Rubber—Natural and Synthetic. Compiled by E. R. Yescombe. Pp. 10. (London: Library Association, 1958.) 2*s*. 6*d*. [129

Department of Scientific and Industrial Research. Forest Products Research. Special Report No. 13: The Longitudinal Permeability of some Hardwoods and Softwoods. By D. N. Smith and Eleanor Lee. Pp. iii+14. (London: H.M. Stationery Office, 1958.) 1*s*. net. [129

Ministry of Agriculture, Fisheries and Food. Bulletin No. 78: A Selected and Classified List of Books relating to Agriculture, Horticulture, etc., in the Library of the Ministry of Agriculture, Fisheries and Food. Pp. vii+96. (London: H.M. Stationery Office, 1958.) 5*s*. 6*d*. net. [129

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Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Season 1956–57. West Indies. By J. R. Spence, C. T. Cave and E. B. Lake. Pp. 10. 1*s*. Kenya. Pp. 14. 1*s*. Survey of Reports. By D. F. Ruston. Pp. 12. 1*s*. (London: Empire Cotton Growing Corporation, 1958.) [129

North of Scotland College of Agriculture. Calendar, 1958–1959. Pp. 116. (Aberdeen: North of Scotland College of Agriculture, 1958.) [129

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British Welding Research Association. Thirteenth Annual Report, 1957–58. Pp. vi+62. (London: British Welding Research Association, 1958.) [129

Department of Scientific and Industrial Research. From Trawler to Trader: an Approach to the Simplification of Handling Methods in Fish Docks. Pp. iii+30. (London: D.S.I.R. Lending Library Unit, 20 Chester Terrace, N.W.1.) [129

Department of Scientific and Industrial Research. Food Investigation Leaflet No. 17: The Principles of Scientific Cleaning for the Fish Industry. Pp. 11. (London: H.M. Stationery Office, 1958.) 1*s*. 3*d*. net. [129

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Other Countries

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 35, No. 5: Birds of Northeastern Peru. By Melvin A. Traylor. Pp. 85–141. 1 dollar. Vol. 36, No. 6: A Geographic Classification of Neotropical Mammals. By Philip Hershkivutz. Pp. 579–620. 1 dollar. (Chicago, Ill.: Chicago Natural History Museum, 1958.) [119

United States Department of Agriculture. Technical Bulletin No. 1185: Soil Conditions That Influence Wind Erosion. By W. S. Chepil. Pp. iii+40. (Washington, D.C.: Government Printing Office, 1958.) 25 cents. [119

Smithsonian Institution: Astrophysical Observatory. Contributions to Astrophysics. Vol. 2, No. 11: Statistics of Meteors in the Earth's Atmosphere. By Gerald S. Hawkins and Richard B. Southworth. Pp. ii+249–364. 50 cents. Vol. 2, No. 12: Granulation and Oscillations of the Solar Atmosphere. By Charles Whitney. Pp. 365–376. 15 cents. (Washington, D.C.: Government Printing Office, 1958.) [119

Union of South Africa. Department of Commerce and Industries: Division of Fisheries. Investigational Report No. 35: The Pilchard of South Africa and of South West Africa (*Sardinops ocellata*). The Variations of Temperature in the Surface Layer of the Sea near Walvis Bay during 1954–57, with an Analysis of some Wind Data from Pelican Point. By G. H. Stander. (Reprint from *Commerce and Industry*, April, 1958.) Pp. 40. (Pretoria: Government Printer, 1958.) [119

Smithsonian Miscellaneous Collections. Vol. 119, No. 3: Mississippian Fauna in Northwestern Sonora, Mexico. By W. H. Easton, John E. Sanders, J. Brookes Knight, and Arthur K. Miller. Pp. vi+87+9 plates. (Publication 4313.) Vol. 135, No. 9: New American Paleozoic Echinoids. By P. M. Kier. Pp. i+28+8 plates. (Publication 4337.) (Washington, D.C.: Smithsonian Institution, 1958.) [119

United States Department of Commerce: National Bureau of Standards. NBS Circular 595: Tables of Transport Integrals $J_n(x) \equiv \int_0^x \frac{e^z z^n \, dz}{(e^z-1)^2}$. By William M. Rogers and Robert L. Powell. Pp. ii+46. (Washington, D.C.: Government Printing Office, 1958.) 40 cents. [119

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 39 (July, 1958): The Influenza Epidemic of 1957–58. Mortality at High Level. Families in the United States and Canada. Fatal Accidents Among Women. Pp. 12. (New York: Metropolitan Life Insurance Company, 1958.) [119

Human Factors Research Bureau, Inc. Publication No. 557: The Guinea Pig in Research: Biology—Nutrition—Physiology. By Dr. Mary Elizabeth Reid. Pp. iv+87. (Washington, D.C.: Human Factors Research Bureau, Inc., 1958.) 2 dollars. [119

Canada. Department of Mines and Technical Surveys: Dominion Observatories. Publications of the Dominion Astrophysical Observatory, Victoria, B.C. Vol. 10, No. 24: H.D. 23642, a Spectrographic Binary in the Pleiades. By Joseph A. Pearce. Pp. 435–445+plate 25. 25 cents. Vol. 11, No. 1: Victoria Observations of 31 Cygni. By A. McKellar and R. M. Petrie. Pp. 1–34+plates 1 and 2. 25 cents. (Ottawa: Queen's Printer, 1958.) [119

The Miracle of an Egg. By R. L. Brahmachary. Pp. v+68. (Calcutta: Research and Training School, Indian Statistical Institute, 1958.) 0.50 dollars. [119

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Ghana. Report on the Department of Soil and Land-Use Survey for the year 1956. Pp. ii+19+3 maps. (Accra: Government Printing Department (Publications Branch); London: Crown Agents for Oversea Governments and Administrations, 1958.) 2*s*. 6*d*. [129

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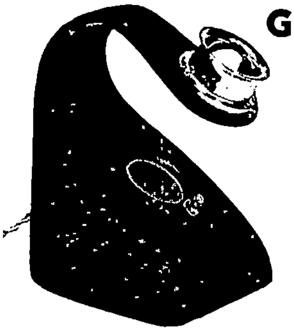

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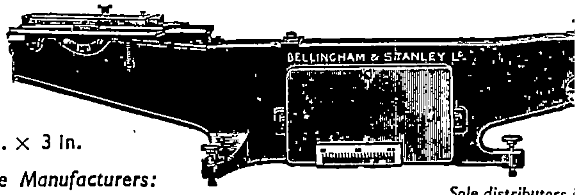

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INTERNATIONAL CO-OPERATION IN SCIENCE AND TECHNOLOGY

PERHAPS the most outstanding feature of the first International Conference on the Peaceful Uses of Nuclear Energy held in August 1955 was the way in which it was regarded by scientists as re-establishing the old spirit of scientific co-operation, and promoting in this field both the contact between scientists which had largely been interrupted and the conditions for the free exchange of ideas upon which scientific advance depends. There has since been a notable increase in the release of information in this field which had been classified as secret, and the establishment of the Eurochemie company and the European Nuclear Energy Agency would scarcely have been possible unless scientists and technologists were relatively free to co-operate and discuss common problems. Moreover, it has become even clearer in the past three years that, in nuclear science, equipment is so costly that only by a co-operative effort can we expect to keep the units in economic use or even provide the resources to construct them.

Nevertheless, in his opening address to the second International Conference on the Peaceful Uses of Atomic Energy on September 1, Prof. Francis Perrin, who began with a reference to the value of co-operation and the stimulus to scientific development and to the improvement of education generally and especially to scientific and technical training which was likely to be the first gain to any country from nuclear energy, found it necessary to stress the foolishness of continued secrecy. These international conferences, he said, render great service to the cause of peace by reducing the barriers of secrecy in vast areas of scientific and technological activity. They gave governments a favourable opportunity to declassify areas of knowledge and thus reveal secrets which are found to be largely identical, though the discoveries have been made independently.

This demonstration of the wastefulness of secrecy in itself leads to the removal of restrictions on further areas of knowledge. The wide interest taken generally in this strictly scientific and technical conference, however, offered Prof. Perrin an unrivalled opportunity, which he did well to use, to explain why it is so important to remove so far as possible the secrecy which, since the Second World War, veiled scientific activities in which exchanges of ideas and publications were formerly free. His exposition of the harm done by secrecy, the loss it causes to humanity, and its limited advantages to those who impose it and the serious drawbacks that result even for them, was addressed not primarily to the scientist but to the politician, and to the world generally, which is so profoundly interested in the industrial uses of nuclear energy.

The most obvious disadvantage of secrecy is its adverse effect on the progress of the sciences where it is introduced, by limiting the exchange of ideas and knowledge to more or less restricted groups, and by requiring each group thus isolated to carry out or repeat all the exploratory and methodological work which could have been shared. This is particularly serious for the weakest groups, as they are condemned to an increasing delay which may eventually render their work sterile; but it also adversely affects the strongest groups, since they are deprived of results that could have been obtained by other less well-endowed groups if they had been kept well-informed and so could have worked along neglected directions rich in possibilities. Even in a situation of abundant scientific and technical man-power, there can never be enough available to explore all the attractive and potential avenues. In the situation of scarcity which characterizes the whole Western world at least, progress in nuclear energy and in any other field depends on our ability to make the fullest possible use of all available knowledge and the elimination so far as possible of all overlapping and duplication of effort. The recent conference should have reminded Great Britain in particular of the importance of concentrating her resources on a few carefully chosen projects rather than diffusing them over too wide a field.

No less important, and particularly in reference to the more creative work at the frontiers of an advancing science or technology, is the harm which secrecy does to all groups by excluding the salutary criticism which often comes most effectively from independent groups. Nor is it simply that such criticism can prevent costly mistakes. It is often a stimulus to new ideas, particularly at the meeting place of different disciplines. Finally, as Prof. Perrin notes, the existence of secrecy may deter the most valuable and creative minds from entering such fields of research.

This retarding of scientific progress he regards as only the least of the evils of secrecy in important sectors of research. It also prevents science from acting as the link between men that its universal character enables it to provide: on the contrary, it engenders distrust and poisons human relations in the sphere where they best allow an intermingling of civilizations. Even in the sphere of Anglo-American relations, misunderstanding and friction have been caused by secrecy, and co-operation has been seriously hindered.

Prof. Perrin may tend to over-estimate the contribution which science can make to international co-operation when he characterizes mutual distrust as the most harmful effect of secrecy. Nevertheless, the activities of the international scientific unions and of the special agencies of the League of Nations between the two World Wars showed that it can exert an important influence; and he is undoubtedly right in referring also to the influence in the formation of character of the practice of the disciplines of scientific research and of teaching the sciences, or even of a severe scientific upbringing. Science requires a perfect sincerity with oneself as well as with others, an objective pursuit of truth which goes beyond its own field and penetrates the nexus of relationships between men. It demands a discipline of thought and expression that rejects the empty emotional bombast that is particularly apt to put peoples against each other.

Now, as Prof. Perrin rightly observed, to enclose important fields of research and scientific work, by preventing the men engaged in them from communicating freely with those studying the same problems in other countries, is to lose all the benefit of the mutual understanding and fraternal feeling in the same task that comes with normal relations between scientists. It is a breach, in a limited but important field, of fundamental human freedoms and rights : freedom of expression and information—the right, even the duty, to impart instruction—the right of all to learn and to know all that has been discovered about the mysteries of Nature. We should not exaggerate the importance of this factor—and Prof. Perrin recognizes that we should not expect scientists to differ morally from other men—but when all allowance is made for the effect of that resistance to knowledge which Dr. J. Trenaman stressed in a recent suggestive address to the Library Association, we can ill afford to neglect any means of strengthening co-operation and understanding between the nations. Even from the negative aspect of removing possible causes of friction or distrust, the restoration of normal relations between men working in the various secret fields of research on the use of nuclear energy is a notable contribution to the strengthening of peace.

The importance of this contribution, in Prof. Perrin's view, depends less on the numbers of these men and their part in the development of major national programmes than on their predominant position in the scientists' awareness of their special responsibility to society. Regarding the bringing of men together as the most valuable result of the Conference, he regretted that the Conference is still not fully representative, and that some great peoples are still absent from these exchanges of ideas and this rebuilding of the international scientific community. Until such conferences are fully representative, their contribution to international goodwill and understanding, whatever their intrinsic merits, will be incomplete.

While, therefore, it is appropriate that, on the scientific and technical plane, due thought should be given to the most appropriate and economic intervals at which such conferences should be held, having regard to the considerable interruption of normal scientific and technical effort which they inevitably involve, this other aspect should be kept in mind. No effort should be spared which promises to make such conferences fully representative of the nations. Put at the very lowest level, they help the nations to live peacefully together in this technological age by emphasizing the positive contribution of nuclear energy to human welfare as against the destructive power of nuclear weapons. To the extent that the area of knowledge and understanding of nuclear energy is widened, an inroad is made into the fear and distrust that hinder international co-operation and are a continuing threat to world peace. For its indirect contribution to that end, no less than for its bearing on the advancement of science and technology and on the most effective use of our own limited resources of both equipment or scientific and technical man-power, scientists and technologists in Great Britain should make sure that the points made by Prof. Perrin regarding the foolishness of secrecy are fully apprehended by the Government. Security considerations must not be allowed to hinder the exchange of scientific and technological knowledge beyond the severest limits that independent—and not departmental or subjective—judgment approves ; and this applies not only in Great Britain but also in every other country of the world which is striving for an era of universal peace and prosperity.

SOCIAL CONDITIONS IN ENGLAND AND WALES

A Survey of Social Conditions in England and Wales as Illustrated by Statistics

By A. M. Carr-Saunders, D. Caradog Jones and C. A. Moser. Pp. xxi+302. (Oxford: Clarendon Press ; London: Oxford University Press, 1958.) 25*s*. net.

IN 1927 Sir Alexander Carr-Saunders and Mr. Caradog Jones published the first edition of their "Survey of the Social Structure of England and Wales, as illustrated by Statistics". A second edition, which incorporated figures from the 1931 census appeared ten years later, and the present volume, which has been entirely rewritten, with Mr. C. A. Moser joining the original team of authors, brings the work up to date, using the mass of material that has appeared since the War.

The authors write as social statisticians rather than as sociologists. Their aim is to provide a factual background, to distil the large volume of statistical information that is now available, so that a clear picture emerges for those who are unfamiliar with the pitfalls besetting the interpretation of official data. They aim at avoiding explicit value judgments, so far as possible, and content themselves with description, rather than comment.

The third edition keeps up the high standard set by the two previous ones ; indeed, in arrangement and coverage it has been improved in many ways. Full use is made of the large amount of new information that has been collected as a result of war and post-war policy. The authors' task of selection and summarizing must have been much more difficult than twenty years ago, though the value of their labours is correspondingly increased. For the student of social conditions the book will be an indispensable starting point.

It is interesting to compare the changes that have been introduced in the present edition. There are chapters on nutrition, health, the use of leisure and religion which did not appear in the 1937 edition, though some of these topics will have been treated elsewhere in that volume. The section on personal expenditure has been greatly expanded, using the data collected by the Central Statistical Office, and in the Ministry of Labour's household expenditure inquiry. On the other hand, the chapters on voluntary provision against misfortune, voluntary transfer from rich to poor, poverty, and the inborn qualities of the population have been omitted in the 1958 edition. A comprehensive chapter on social security has been substituted. The sections on education and on crime have been completely recast. The result is a clear picture of social conditions in Britain to-day, in so far as statistics are available to illustrate them. The qualification is important. In spite of the considerable improvement that has taken place in the provision of statistical data, there are still gaps, particularly in social statistics. Thus, the authors comment that national statistics dealing with the distribution of personal property "hardly exist" and figures on personal incomes are "sparse enough". They might have added that income which is liable to and declared for income tax purposes is not always the same as spendable resources. Moreover, most of these data are global in character and it is not possible, as a general rule, to trace the distribution of incomes in particular social or economic groups.

However, the general picture that emerges is that of a society in which inequalities have been reduced, in some cases not inconsiderably, during the past twenty years. There is, however, no ground for complacency on this account. Thus, in the chapter on nutrition it is stated without qualification that the diet of larger households is still inadequate and that some of the deficiencies are not negligible. As regards the ownership of property, the authors quote the Oxford Survey's figure which shows that one-third of all households have no liquid assets at all, a far cry from the picture of a 'property-owning democracy'.

There is one surprising omission: no use is made of the census of distribution to show the structure of wholesale and retail distribution; the auth[illegible]bly regarded this as part of the 'economic' ra[illegible]an the 'social' conditions of England and Wal[illegible]ere is one error which ought to be pointed out [illegible]der to restore peace of mind to happily m[illegible]ried readers of the book. The statement on p. [illegible] that "the longer a marriage has lasted, the greater the chance of divorce" is not correct. The risk of divorce, in fact, decreases after a marriage has lasted for about ten years.

E. Grebenik

COLORIMETRIC ANALYSIS

Colorimetric Determination of Nonmetals

Edited by David F. Boltz. (Chemical Analysis: a Series of Monographs on Analytical Chemistry and Its Applications, Vol. 8.) Pp. xii+372. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1958.) 8.50 dollars.

This book, Vol. 8, of a series of monographs, may be regarded as supplementary to Prof. Sandell's "Colorimetric Determination of Traces of Metals" (Vol. 3 of the series).

Chapter 1 of the present volume deals quite adequately in twenty-eight pages with principles and practices in colorimetric analysis. Subsequent chapters, written by specialist authors, deal with the individual elements, each chapter being subdivided into sections concerning separations, methods of determination and applications.

The methods described for the determination of phosphorus are those based on the development of molybdenum blue and on the formation of molybdovanadophosphoric acid and molybdophosphoric acid, due attention being paid to possible interferences. Applications dealt with are the determination of phosphate in industrial waters and of phosphorus in steel, serum, and copper base alloys (26 references).

The chapter on silicon deals mainly with applications of the molybdosilicic acid method and the heteropoly blue complex method. Methods for the determination of silicon in various alloys, steel, water, biological materials, foods and agricultural material are described (31 references).

There follows a very comprehensive chapter of 85 pages on nitrogen. A section dealing with Kjeldahl digestion provides a useful summary, including a discussion of the effectiveness of some catalysts, and has applications obviously not limited to colorimetric determinations. The recovery of ammonia by distillation, aeration, and microdiffusion, and all aspects of the Nessler method, are dealt with in considerable detail. Other methods are discussed. Practical details are given for the determination of various forms of nitrogen in water, sewage, biological materials, soil, plants, steel, zirconium and petroleum products, and the sections concerned with nitrite and nitrate include descriptions of methods for the determination of oxides of nitrogen in air (203 references).

The chapter on chlorine is concerned with *o*-tolidine, methyl orange and König reaction methods for free chlorine, nephelometric, silver chromate, silver phosphate and mercuric nitrate methods for chloride, benzidine and nephelometric methods for chlorate, a benzidine method for hypochlorite, and a methylene blue method for perchlorate (37 references).

For the determination of bromine, the colorimetric methods described are preceded by volatilization as free bromine or cyanogen bromide or by oxidation to bromate. The colorimetry is based on König's reaction or on reactions with methyl orange, phenol red, rosaniline, fluorescein or gold chloride. Specific applications described are concerned with the determination of bromine in flour, blood, sea water and brine (34 references).

Preliminary separations dealt with in the chapter on iodine are distillation, extraction by solvents such as toluene, and microdiffusion. Organic matter is destroyed by alkaline ashing or by treatment with acid oxidants, under conditions which are stated to cause no loss of iodine. For the actual determinations, the methods given pride of place and discussed in considerable detail are based on the catalytic effect of iodide on the reduction of cerium-IV by arsenic-III. Probably the average chemist would prefer the more direct colorimetric methods, such as starch–iodine methods (which are also described). Methods based on the extraction of iodide from saturated potassium carbonate solutions and on the oxidation of iodide to iodate by bromine water are not described (127 references).

The chapter on fluorine commences with a discussion of the correct design of apparatus for the Willard and Winter distillation, of the distillation procedure, and of factors that affect quantitative recovery. Other methods of separation receive brief mention. Of all the methods of determination considered, including the zirconium and thorium alizarin methods, a zirconium eriochrome cyanine *R* method is considered most generally suited for photometric analysis. Methods are given for the determination of fluorine in urine, teeth and bones, blood and soft tissues, agricultural samples and water (38 references).

The earlier pages of the chapter on sulphur contain notes on a large number of published methods for the separation and determination of inorganic and organic sulphur. Among methods which receive some detailed consideration are the methylene blue method based on the reaction of sulphide with *p*-aminodimethylaniline in the presence of ferric chloride, and the barium sulphate turbidimetric method. Procedures described in detail include determinations of hydrogen sulphide in gases, of free sulphur in air and in hydrocarbons, of sulphate by benzidine precipitation and diazotization, of sulphur in plants, wool and soils, of sulphides in water and alkalis, and of aliphatic sulphides in hydrocarbons by ultra-violet absorption after reaction with iodine (132 references).

A brief summary of the general chemistry of tellurium and selenium precedes the sections on separations and methods. Following a review, comprising notes on published work, the absorptiometric methods described are based on the formation of iodotellurite, of addition compounds with sulphuric acid, of a compound with diaminobenzidine, and of the tellurium thiourea complex. A colorimetric iodine method for selenium is included. Procedures are given for the determination of selenium in natural waters, copper, steel and arsenic, and of tellurium in lead and copper (46 references).

The chapter on boron commences with notes on precautions, such as avoidance of contamination and loss. Separations are based on distillation as methyl borate, preferably in the cyclic apparatus illustrated. Reactions with quinalizarin, carminic acid, dianthramide or curcumin are used for the actual determinations. Procedures for the determination of boron in steel and alloy steels are given (22 references).

The book contains much very useful information: in general, the treatment is thorough and the choice of methods good.

C. O. HARVEY

THE BILE SOLID

Cholesterol

Chemistry, Biochemistry, and Pathology. Edited by Robert P. Cook. Pp. xii+542. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 15 dollars.

DR. R. P. COOK must have wondered whether a book of this title could be usefully compiled. He need not have worried: he and his team have done well. The work he has edited is a comprehensive survey of most important work (to the end of 1957) on cholesterol; it includes much material on other sterols and more than a little on steroids in general.

A short historical introduction, appropriately written by Henrik Dam, is followed by a thorough, if condensed, chemical survey by Peter Bladon. This includes sections on nomenclature, on physico-chemical measurements on steroids, on digitonide and other complex formation and on colour reactions. There are tables of natural sterols, and of physical constants (melting points, optical rotations and ultra-violet spectra) of cholesterol derivatives.

R. P. Cook and J. B. M. Rattray then give a chapter on methods of isolation and estimation of sterols; R. P. Cook describes their distribution in organisms and plant and animal tissues. G. S. Boyd and M. F. Oliver discuss the physiology of blood cholesterol and of lipoproteins in man and other species. R. G. Gould thoroughly reviews our knowledge of sterol biosynthesis, and O. Hechter the conversion of cholesterol to steroid hormones. Geoffrey Bourne contributes a thoughtful and provocative essay on the histological demonstration of cholesterol and on its possible functions in cells. Metabolism in the normal animal is dealt with by R. G. Gould and R. P. Cook, and David Adlersberg and Harry Sobotka discuss pathology. The important and highly topical subject of treatment of disorders of cholesterol metabolism is briefly reviewed by I. H. Page. W. Bergmann contributes a chapter on evolution and sterol distribution, Marjorie Horning discusses sterol requirements of insects and protozoa, and Thressa Stadtman writes about microbial metabolism of steroids.

The book ends with R. P. Cook's account of metabolic relationships between cholesterol and other lipids, and there is an appendix on practical methods of extraction, purification and estimation of sterols and lipoproteins.

The book is thoroughly documented throughout, and it has an adequate index. Its format and illustrations are excellent.

More than all this, it is, for the most part, well and clearly written. Dr. Cook has clearly been a tactful and liberal editor; moreover, he and his collaborators have somehow conveyed a sense of history and of the broad sweep of biochemical advance into a work that might easily have been a dry and dull collection of data.

All interested in its subject-matter will want to have an[illegible]ng, will want to read this admirable volume.

G. A. D. HASLEWOOD

STABILITY OF NON-LINEAR SYSTEMS

Differential Equations

Geometric Theory. By Solomon Lefschetz. (Pure and Applied Mathematics: a Series of Texts and Monographs, Vol. 6.) Pp. x+264. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 9.50 dollars.

A STANDARD set of differential equations can be taken in the form:

$$dx/dt = X(x,t)$$

where x,X are n-dimensional vectors, t can be thought of as the time, and a solution $x(t)$ is a curve, or trajectory, in the n-space. This formulation shows the need for some matrix technique and some knowledge of simple topological concepts. The important idea of stability then appears in the statement that a trajectory from a given initial point is stable if, roughly speaking, another trajectory starting from a neighbouring initial point nowhere departs substantially from the former.

After introductory chapters on existence theorems and linear systems, Lefschetz defines various types of stability and examines them in detail for certain important forms of the function $X(x,t)$ such as $Px + q$, where P is a matrix which is either constant or a function of t only, and q is a vector, depending on x and t, which is, in some sense or other, small compared with x. If P is a constant matrix, and q is ignored to get a first approximation, the set of equations is a linear set with constant coefficients, and we may hope that the solution of this simple set will indicate the dominant stability features of the more general set. Much of the content of this section stems from Liapunov's classical monograph on the general problem of stability (1892), but Lefschetz brings the development right up to date by collecting all the salient points from recent research work.

In the latter half of the book, the n-space is specialized to two dimensions. When X is independent of t the equations are said to be autonomous, and in Cartesian form are:

$$dx/dt = f(x,y), \quad dy/dt = g(x,y)$$

The trajectories, which in the autonomous case are called paths by Lefschetz, are studied in considerable detail and much geometrical information about them is obtained, for various special forms of f and g. Then second-order non-linear equations, including the famous van der Pol equation for triode oscillations, are discussed with emphasis on the phase-plane representations: they are reduced to a pair of first-order equations, which may be autonomous, or, as in the case of the Cartwright–Littlewood equation, may contain a function of t on the right-hand side. Finally, there is a chapter on oscillations in a quasi-harmonic system, differing from the simple harmonic equation by a small, variable, perturbation term: Poincaré's perturbation method, and the time-averaging method originated by van der Pol, are described.

Lefschetz's exposition is, as always, vivid and stimulating, and does not demand a great deal of specialized equipment; although some previous acquaintance with matrix notation and the idea of a compact space is desirable, the book itself contains an excellent summary of what is wanted on these topics. In the main sections, the reader will find that he is expected to be quick in grasping new ideas, and should allow himself frequent pauses for assimilation. For the young research student wishing to begin work in this wide and important field, the volume will prove invaluable.

T. A. A. Broadbent

STRUCTURE OF ATOMIC NUCLEI

Handbuch der Physik

Herausgegeben von S. Flügge. Band 39: Bau der Atomkerne. Pp. vi+566. (Berlin: Springer-Verlag, 1957.). 125 D.M.

THIS volume comprises chapters on the two-nucleon problem by Prof. Lamek Hulthén (Stockholm), and Prof. Masao Sugawara (Hokkaido); on the three-body problem in nuclear physics by Prof. Mario Verde (Torino); on the distribution of matter and charge within atomic nuclei by Dr. D. L. Hill (Los Alamos); on the nuclear shell-model by Dr. J. P. Elliott, and Dr. A. M. Lane (Harwell); and on models of nuclear structure by Prof. Steven A. Moszkowski (University of California, Los Angeles).

Profs. Hulthén and Sugawara's contribution, in Chapter 2, gives a complete and compact summary of the experimental data on the two-nucleon problem available up to 1956. The treatment of theoretical questions required for the interpretation of the experimental observations is based on static nuclear potentials as derived from the pseudoscalar field theory. The main merit of this review lies in the careful analysis of the observational data (mostly in the low-energy region) in terms of central forces and the effects achieved when a tensor force is introduced. Sections on high-energy scattering and photo-effect and a mathematical appendix (by Prof. Sugawara) conclude an exemplary piece of scientific reporting. Unfortunately, the recent observations of the polarization of p and n on scattering, of importance in resolving ambiguities in the phase-shift analysis, could not be included. The section on three-body problems and that on matter and charge distribution in nuclei complete what one could call the first part of this volume. Dr. Hill's article illustrates in detail how a single property, such as the finite size of the nucleus and its charge distribution, sometimes has observable effects on a great many atomic and nuclear properties.

The experimental physicist who works in a high-voltage laboratory with a cyclotron and studies the unstable elements will certainly find the second part of the volume dealing with nuclear models particularly welcome. The two articles by Elliott and Lane and by Moszkowski contain everything that the research physicist needs for analysing his data in terms of the mechanism which underlies his observation. It also seems that the review of the shell model is complete in so far as theory is concerned, so that all tools for shell model calculations are at the reader's disposal within its 170 pages; to ease readability, much formal mathematics is placed in eleven appendixes. Dr. Moszkowski's survey of nuclear models offers a lucid and most readable exposé of a mainly non-mathematical character. The general approach is nevertheless that of a theoretician, who ably supports his statements with experimental data. The whole is excellently organized, preventing confusion which could easily arise when one looks at Table 1 with its list of sixteen models. I drew considerable courage from this diversity, since we are not likely to run out of problems during the next five years (though we may do so within ten years), unless Brueckner's theory provides a sudden solution.

Of the total 550 pages in this book, 240 are used for the first three contributions and 310 are devoted to nuclear models. All the contributions are written, in English, by theoretical physicists, 42 per cent of the volume being written by authors working in government laboratories in Britain or the United States, though the topics covered are only remotely connected with the immediate interests of these institutions. They reveal a very high standard of scholarship indeed.

This volume should be within easy reach of all workers engaged on research in the fields covered; it would be so, were it not that the price confines it to libraries, where it will mostly be out on loan. The printing, illustrations and accuracy are of the highest order.

E. Bretscher

RECENT DEVELOPMENTS IN NUCLEAR ENGINEERING*

By SIR JOHN COCKCROFT, O.M., K.C.B., C.B.E., F.R.S.

THE second Geneva Conference on the Peaceful Uses of Atomic Energy revealed the progress in nuclear engineering which has been made during the three years since the first conference.

British experience in operating Calder Hall now extends over two years. The total electrical power generation up to September 1958 has been 938 million kWh., representing a full load power factor of 67 per cent on reactor No. 1 and 81 per cent on reactor No. 2. These high load factors have been achieved in spite of the fact that in this prototype design it is necessary to shut down and release the carbon dioxide pressure before a fuel rod can be changed, this operation taking an appreciable time. During the life-time of the first charge of fuel, only three fuel elements out of the ten thousand developed faults, and so far there has only been one fault in the second charge. In the first charge of reactor No. 2 there have been four positively identified faulty fuel elements, and six channels have been discharged for examination because of rather large signals from the faulty fuel element detector equipment. The fault is usually due to a slight leakage developing in the weld of the magnox alloy can. This allows slow penetration of the carbon dioxide coolant, with resulting oxidization and a slow outleakage of fission products. This usually develops rather slowly, so that fuel elements can be changed when convenient over a period of a week or two. We have had one or two incidences of a more rapid development of a leakage due to a defective weld.

Apart from shutdowns due to the necessity to change faulty fuel elements and to change the whole charge at the end of its life, reactors and power units can go on operating for very long periods; indeed, one reactor operated continuously for six months. Maintenance can be carried out on a single cooling circuit or associated electrical equipment by closing off this circuit and reducing power for an hour or so. There is, in fact, little to go wrong in a graphite-moderated reactor except the fuel elements. No automatic control rod circuits are installed in the Calder Hall reactors, but the circuit has proved to be remarkably stable. The temperature of the fuel element stays constant to ± 1 deg., and there is a similar stability of power-level. In some very large reactors the distribution of power generated in different parts of the reactor can vary slowly over a period of days, due to the accumulation of the fission gas, radioxenon. As a result of this, an increase in power density on one section of the reactor can burn up more xenon and so increase the reactivity, and the opposite effect can occur in another part of the reactor. These very slow spatial oscillations have not so far been observed in Calder Hall.

Initially, with a new charge, the temperature coefficient of reactivity associated with increases of temperature of fuel elements and of moderator is negative and the system is entirely self-stabilizing. As the radiation of the fuel proceeds, the increasing quantity of plutonium fuel modifies the delayed temperature coefficient associated with the moderator temperature, making it increasingly positive; but the prompt coefficient of temperature associated with the fuel-element temperature remains negative. After an irradiation of about 400 MW. days per ton, the moderator temperature coefficient is about $+ 4 \times 10^{-5}$ in K/degree centigrade. It is expected to reach a saturation-level of about 15×10^{-5} with very long irradiation. The overall effect of this limiting value of the temperature coefficient would be that small increases in power-level could be doubled in a time of about two minutes if no movement of control rods were made to correct this. So after a thermal power-level change of 200–201 MW., the level would increase to 202 MW. in two minutes and to 204 MW. in four minutes.

These effects of the positive temperature coefficient occurring over such relatively long periods of time do not require any changes in the normal control of a station, and indeed they are not generally observable to the operator since general small circuit fluctuations require small corrective action to be taken on a similar time-scale. These are examples of the wide range of operational experience we have gained during the past two years. This experience has given us great confidence in this type of power station.

The Shippingport nuclear power station uses a pressurized water reactor to produce 230 MW. of heat, leading to 60 MW. of electricity. This power station went into operation on December 18, 1957, and a brief account of its operational characteristics was given at the recent Geneva Conference on the Peaceful Uses of Atomic Energy. The time taken to get the power station on load from ambient temperature is 8 hr., this being set by thermal stress. The reactor operation has a high negative coefficient of reactivity. On one occasion the condenser vacuum was lost and the turbine shut down automatically. The negative temperature coefficient reduced the reactor output to essentially zero without any movement of control rods, the only effect on the plant being an increase of system pressure from 2,000 to 2,160 lb. sq. in.

The first Russian large-scale nuclear power station came into operation during the period of the Geneva Conference. The power station is to consist of six identical 100-MW. electrical units. The heat source is a graphite-moderated water-cooled reactor, apparently scaled up from the 5-MW. power station reported at the 1955 Geneva Conference. The reactor has pressure tubes of stainless steel to separate the high-pressure coolant from the graphite. The fuel is natural uranium. Steam reaches the turbines at a pressure of 90 lb./sq. in. at 185° C. The power station seems to be a dual-purpose plant. It is the first major contribution to the U.S.S.R. 2,000-MW. programme of nuclear power stations.

None of these three power stations was designed as a commercial nuclear power station. They are either prototypes or dual-purpose reactors, and their capital costs per kW. hr. are high.

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*Substance of a lecture to the Danish Society of Civil Engineers, delivered on October 6.

The second generation of nuclear power stations are very different. They have usually been designed specifically as power stations for electricity authorities. In Britain they include four graphite-moderated carbon dioxide cooled reactor power stations due for completion at dates ranging from 1960 to 1962 with outputs ranging from 275 to 500 MW. for a two-reactor station. In the United States there are under construction two pressurized-water and one boiling-water reactor power stations having outputs ranging from 134 MW. electrical to 275 MW.(e), the latter being boosted by 110 MW. of oil superheating. In addition, a 100-MW.(e) electrical fast reactor is being constructed. All these are due for completion by the end of 1960. The French are building two graphite-moderated carbon dioxide cooled reactor power stations of 63 MW. and 170 MW., respectively, for completion by about the same period. Italy is to build one British type of power station and one station similar to the U.S. Dresden power station, using a boiling-water reactor as heat source. The Russians are building two 420-MW. stations, each using two pressurized-water reactors. They are also building a 400-MW. power station using four graphite-moderated reactors in which the steam is superheated inside the reactor.

The British stations are typified by the Somerset power station, which is to generate 500 MW.(e). Each reactor contains about three times as much uranium as in the Calder Hall reactors. The pressure of the carbon dioxide coolant is 85 per cent higher than Calder Hall. The fuel element surface temperature is 430° C. compared with 408° C. at Calder Hall. The heat-transfer surfaces of the fuel elements have also been improved over Calder Hall. The effect of this increased pressure, increased temperature and improved surface has been to increase the average rating from the 1·4 MW./ton in Calder Hall, to 2·6 MW./ton at Hinckley Point. This has resulted in reactor capital costs being reduced by about 20 per cent from the first of the four power stations, and is now of the order of £110 per kilowatt exclusive of costs of fuel and site preparation. For the purpose of economic forecast, the fuel elements have been assumed to achieve an average heat output of 3,000 MW. per ton. Reactivity changes due to substitution of plutonium for uranium-235 and accumulation of fission products will not limit the life of fuel elements before appreciably longer burnups. The limit will probably be set at first by metallurgical imperfections. We have so far accumulated experience of burnup of metallic fuel elements to about 1,200 MW. days/ton in Calder Hall. Fuel elements are undamaged at this burnup and we are steadily extending our experience. The Electricity Authority reactors will operate fuel elements at higher temperatures and ratings. The main new phenomenon to be looked for is swelling of the uranium due to collection of fission gases in bubbles. This could lead to appreciable changes of volume, though we do not expect these to exceed about 10 per cent. The magnesium alloy cans have been designed to withstand volume changes of about 25 per cent. Recently we have shown that the observed swelling in small specimens can be much influenced by temperature cycles, and by restraining the amplitude of the cycling the swelling can be substantially reduced.

It has been stated by the Electricity Authority that with a 75 per cent load factor, 5 per cent interest rate and 20-year write off, and a burnup of 3,000 MW. days/ton, the Somerset nuclear power station just about breaks even, since it is situated in an area remote from coal-fields and conventional fuel costs are consequently high.

The American design thought to be most competitive is typified by the Dresden 180-MW. power station. This is served by a dual-cycle boiling-water reactor. The steam – water mixture produced in the reactor core flows from the reactor vessel to a primary steam drum at the reactor pressure of 1,000 lb./sq. in. The steam then flows to the turbine through the primary steam lines, and the water flows to the secondary steam generator where additional energy is removed to produce steam at a low pressure of 500 lb./sq. in. Valuable information on the stability characteristics of boiling-water reactors has been obtained from the experimental boiling-water reactors at the Argonne Laboratory, at Arco and at Vallecitos.

The contract price of the Dresden nuclear reactor was quoted as about £85 per kilowatt exclusive of research and development costs and fuel charges. The actual costs were stated to be higher than the contract price. The Dresden reactor had a fuel charge of 60 tons of uranium containing 1·5 per cent uranium-235 in the form of uranium oxide clad with zirconium. A burnup of 10,000 MW. days/ton is assumed in the economic forecast. Fuel is costed at American prices of the order of £50,000 per ton. and is to be hired at 4 per cent from the U.S. Atomic Energy Commission. The operator has, in addition, to pay for the uranium-235 burnt. On this basis, fuel costs are likely to be at least 3 mils per kWh. and overall costs were stated to be 7·5 mils. Since, however, the actual capital costs were not stated, this does not mean that commercial nuclear power has arrived in the United States. Indeed, it was stated at Geneva that in the United States nuclear power stations could not reach parity with commercial power before the stations which would start to be built in the late 1960's. This reflects the low present cost of power generated from cheap Kentucky coal or natural gas or hydro-power.

In other countries the date for reaching parity will depend on the cost of indigenous or imported fuel, the interest rates and the load factor available. The World Bank reported at Geneva an interesting study in the economics of nuclear power for a 130–150 MW. station to be erected in southern Italy. Bids were obtained from nine industrial organizations in the United States, Great Britain and France. The results were summarized in Geneva. Nuclear power costs for the most favoured bid were expected to be about 10 per cent above the cost of power from oil- (coal-) fired stations using oil (coal) at £9 10s. per long ton. This assumes a return on investment of 14 per cent and a load factor of 80 per cent.

The Geneva Conference also gave a forecast of the developments in progress towards the third generation of nuclear power stations, which may come into operation in the late 1960's. The major United Kingdom objective will be to reduce capital costs 20–30 per cent below those achieved from the improvement in the second-generation power stations. Capital costs can be reduced by increase of rating, so that more output can be obtained for a given volume of reactor. However, the reactor is already contributing less than 40 per cent of the whole cost. Heat exchangers and the conventional power house contribute more than half the cost. So their costs must also be substantially reduced. This can only be done by increasing the temperature of operation and improving steam conditions.

In Britain an advanced gas-cooled reactor nuclear power station is being built as a reactor experiment to produce the advanced techniques which will be necessary to achieve this. The reactor will use uranium oxide fuel canned in beryllium. This should enable surface fuel temperature to be run to 600° C., giving an outlet temperature for bulk gas of between 500° and 570° C. The fuel elements will consist of a bundle of rods of small diameter. The reactor rating will then be increased from the 2·3 MW. per ton at Hinkley Point to about 8 MW. per ton. The reactor experiment will develop 100 MW. thermal and 28 MW. electrical. Since the plant will be purely experimental, a single-pressure steam cycle will be used with the modest steam condition of 600 lb./sq. in. An appreciably higher efficiency should be obtained with the more complex steam cycle which will be possible in the full-scale power station designed to use this advanced technology.

The use of uranium oxide fuel will require a slight degree of enrichment of the uranium—roughly 1·2 per cent of uranium-235 in the reactor experiment and a lower enrichment for full-scale stations. The enrichment could be provided by plutonium oxide from the second generation of nuclear power stations. Uranium oxide fuel is now being intensively studied, and especially valuable reports came from Chalk River. The fuel has great stability to irradiation, though it cracks as a result of thermal shock, so that it relies on the can for restraint. American companies, backed by a guarantee from the U.S. Atomic Energy Commission, are promising a burnup of 10,000 MW. days/ton, and small specimens are reported to have withstood 25,000 MW. days/ton without appreciable damage.

The present Canadian philosophy of power reactor development is to use a heavy-water moderator, allowing natural uranium oxide fuel to be used. It is then hoped to achieve a burnup of the order of 8,000 MW. days/ton and to write off the fuel at the end of the cycle. In this way it is hoped to achieve fuel costs declining from 1·5 mils to 1 mil and so achieve competitive nuclear power in Canada. The heavy-water gas, or water or steam-cooled reactor is undoubtedly one of the serious competitors for a place in the nuclear power station of the future.

We also heard of the progress of three recent experiments employing a different technology. The 10-MW. organic liquid – moderated reactor experiment at Arco uses a diphenyl or terphenyl moderator. This has a comparatively high stability to irradiation, about 100 lb. of polymer being formed per MW. day of heat. Coolant make-up costs 0·75–1·8 mils per electrical kWh., with a present probable value of about 1·2 mils. The use of an organic moderator has the advantage of a low pressure of about 13 atmospheres, with the surface temperature of fuel elements at 420° C. and a temperature of the bulk coolant ranging from 260° to 270° C. Another attractive feature of cooling by organic liquid is the low level of radioactivity of the coolant, which makes possible maintenance of the primary circuit, even during reactor operation. The reactor uses cermet fuel elements consisting of a 20-mil plate of uranium oxide in stainless steel clad in 5 mils of stainless steel. 26 kgm. of uranium-235 are used.

Good operational experience has been reported for this reactor. The system shows considerable promise for ship propulsion and for power stations with output in the 10–30-MW. range. It should have low capital costs, though whether these can be competitive with Diesel propulsion units remains to be seen. Fuel costs at the prices of American enriched fuel and loan charge would be expected to break even with the costs of oil fuel for ship propulsion systems.

The sodium-cooled graphite-moderated reactor experiment at the North American Aviation Company represents another experiment in reactor technology. The use of liquid sodium as a coolant offers the technical advantage of a high operating temperature with moderate pressure. These are offset by the compatibility problems characteristic of liquid sodium and the consequent need to keep the oxygen content at a level of a few parts per million. The graphite moderator has to be separated from the liquid sodium since it is not compatible with it, so that the graphite bricks are canned in zirconium, which is somewhat of a complication. We carried out a detailed design study on this reactor in the United Kingdom and have decided not to proceed with it.

The Oak Ridge homogeneous aqueous 10-MW. reactor experiment was also described. In this reactor a fluid fuel of uranyl sulphate is contained in a zircalloy core vessel. This is surrounded by a blanket containing a slurry of thorium oxide which captures escaping neutrons and so gives the reactor a breeding potential. Two difficulties have occurred in this reactor. First, corrosion of the wall of the core vessel led to a leakage from core to blanket, so the reactor has at present to operate as a one-zone system. Secondly, there are problems concerned with the stability of the liquid fuel. The future of this reactor system will depend on the results of the experimental programme.

The fast reactor constitutes the fourth class of reactor experiments. So far, only experience on the American 1-MW. fast reactor has been reported. The experiment showed that instabilities occurred due to the geometry of the core fuel rods. This has now been redesigned and the difficulty eliminated. 60-MW. reactor experiments are due to be commissioned in the United Kingdom in 1959 and in the United States in 1960, and a 5-MW. reactor experiment is just going into operation in the U.S.S.R.

Fast reactors have a core of very small size and a corresponding very high rating. For this reason their capital costs should be low. On the other hand, the fact of a large rating produces severe technological problems, and only experience with the reactor experiment will show whether they can be solved. Fuel costs should in principle be low, since they would be fuelled by plutonium from second-generation reactors, presumably at the 'civil price' of about £5 per gm. The reactor should have a breeding factor of at least 1·5 and should turn over the fuel in about 1,000 days. The fuel costs will, however, be dominated by the number of times it is necessary to re-process the fuel during its life, and the cost of making the re-processed fuel into new fuel elements. To minimize these costs, the United States and the United Kingdom are developing the so-called pyro-metallurgical processing system, in which the fuel is melted and the unwanted fission products skimmed off, leaving behind some fission products which, when alloyed with plutonium, have been shown to have good stability to radiation. Until we know more about re-cycling costs, the economic future of fast reactors will remain obscure.

The technical feasibility of the nuclear propulsion of shipping has been abundantly demonstrated by the voyages of the U.S. submarine *Nautilus*, culminating in the remarkable voyage underneath the polar ice cap. The pressurized-water reactor used to develop steam for its propulsion has proved to be highly reliable. We heard at Geneva of the first approaches to commercial nuclear propulsion. The U.S. *Savannah*, a combined passenger-cargo ship coming into commission in 1960, will use a pressurized-water reactor developing 22,000 shaft horse-power. The pressurized-water propulsion unit seems likely to achieve fuel costs based on American prices about equal to those for oil fuel. Present capital costs are, however, three to four times higher than conventional capital costs, and a drastic reduction of these costs is necessary before parity with conventional propulsion is achieved. American engineers expect to build a nuclear tanker using a boiling-water reactor for propulsion by 1962. Since this type of reactor appears to have lower capital costs than the pressurized-water reactor, this should help to bridge the gap, though operating costs will still be well above conventional costs. It seems likely that we shall have to wait five years or more before we shall know whether truly commercial nuclear propulsion is a feasibility. However, there is one immediate application which would be impossible without nuclear power. The opening up of the 6,000-mile seaway north of the U.S.S.R. has had to wait for the practically unlimited endurance of the nuclear propulsion unit. The ice-breaker *Lenin*, which is due to be commissioned in 1959, will have three pressurized-water reactors installed, and two of these will provide 44,000 shaft horse-power for propulsion.

In contrast with the hopeful outlook for marine applications, commercial nuclear aircraft propulsion seems much further away.

EFFECTS OF WEATHER ON PLANT BEHAVIOUR

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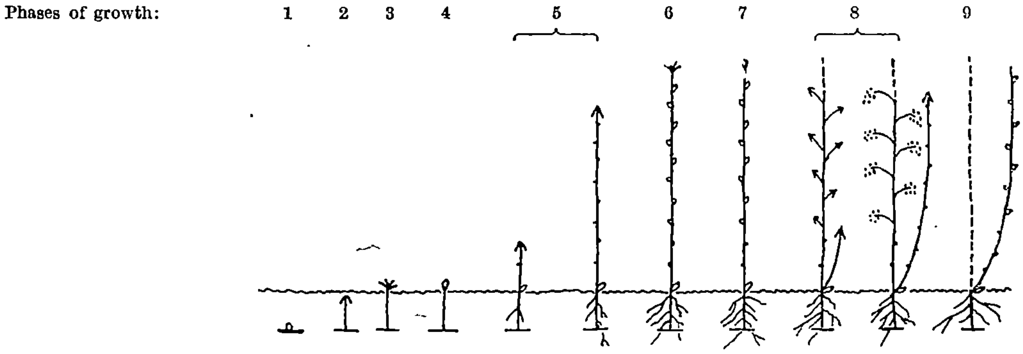
CROP yields vary enormously from year to year and from farm to farm, but record crops, produced by the best managers in exceptionally favourable seasons, show how far yields usually fall below the full cropping capacity of the varieties which are at present available. One of the challenges in agronomy is to show how average yields could be increased. Since 'the weather' plays such an important part in determining the behaviour of plants, a more precise knowledge of the effects of environmental factors would be extremely useful in agriculture. In the first place, knowledge of varietal preferences would make it easier to select the variety most likely to yield heavily in any particular site, provided sufficient meteorological data were available to enable the pattern of probable weather conditions to be forecast. Thus the critical matching of variety to district, on which successful agriculture largely depends, would be placed on a firmer footing than by the traditional and time-consuming method of trial and error.

Another advantage of a fuller knowledge of response to environment is that, once the plant's requirements are known, it is sometimes practicable to exercise a degree of control over the environment itself, to provide conditions which are more nearly optimal for growth. An obvious example is the control of soil moisture and soil salinity, by the complementary techniques of irrigation and drainage, which now make it possible for crops to be grown on some two hundred million acres of land throughout the world which could not otherwise be used for agriculture. Less spectacular, though still useful, methods of environmental control on an agricultural scale are the reduction of air speeds by the use of windbreaks, and the reduction of light intensity by the use of shade trees in the production of some plantation crops. In horticulture, the grower often goes much further by using devices like cloches, frames and heated glasshouses which change such factors as temperature, wind speed and, to a lesser extent, light.

Much research is now being done on the effects of environmental factors on plant behaviour[1,2] and the possibilities of controlling these factors in crop production, but the position is frustrating. Apart from the control of water, and reduction of wind and light intensity, there seems to be little hope of affecting the other physical factors of the environment on a field scale. This is particularly the case with the two important factors of temperature and day-length, both of which have profound effects on the behaviour of many crop plants, and it is difficult to see how control of physical factors of the environment (apart from water) can make any substantial contribution to increasing yields of the major food crops in the immediate future. This is an unwelcome conclusion to those who are working on the agronomical uses of environmental control, but one which must nevertheless be accepted.

However, there is another possible approach. If it is impracticable to affect plant behaviour in the field by altering the nature of its environment, might it not be possible to alter the plant's responses to the natural environment ? For example, the use of a chemical treatment to affect the responses of a plant to temperature or day-length would be a much more elegant device than to try to alter those weather factors on a field scale. The results of some recent experiments suggest that this approach is worth considering.

The work has mainly been done on the raspberry (*Rubus idaeus* L.), which is not itself of much importance in world cropping, but was chosen because of its great convenience as an experimental plant. The pattern of the work has been, first, to study the behaviour of the species in the field, in order to distinguish between successive phases in the life-cycle, with particular emphasis on the behaviour of the stem apices. Next, plants have been grown in



Time scale	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn
	1956		●		1957		●		1958	
Emphasis on :										
Vegetative aspects										
Leaf initiation	+			+	+			+	+	
Internode elongation		+		+	+			+	+	
Leaf expansion		+		+	+	+		+	+	+
Dormancy			+				+			
Floral aspects										
Flower initiation						+				+
Breaking dormancy							+			
Flowering and fruiting								+	+	
Senescence and death										+

Fig. 1. Diagram showing the phases of development of a raspberry shoot growing in a temperate climate, and the behaviour of the apical meristem(s) characteristic of each phase

controlled environments (growth rooms), to ascertain which types of 'weather' (that is, which levels of temperature, day-length and/or light intensity) cause the shoots to pass from one phase of development to the next. Thirdly, plants have been grown in environments which represented marginal weather conditions, where shoots are just 'held' in one phase and prevented from progressing to the next, and the shoots have then been treated with chemical stimulants to see whether they could be induced to pass to the next phase in weather conditions which would normally prevent that development from occurring.

The raspberry plant lends itself to such an investigation since suckers which arise from adventitious buds on the perennial root systems have life-cycles which can be divided into a number of discrete phases, in each of which the apices behave in different ways (Fig. 1). Under natural weather conditions in a temperate climate, leaf initials are laid down in the subterranean bud in phase 1, internodes elongate to carry the apex to the soil surface in phase 2, while leaves expand in phase 3, but internodes cease to elongate, and a rosette of leaves is formed. Thus, in the first three phases the three major phenomena of vegetative apices, namely, leaf initiation, internode elongation and leaf expansion, are each dominant in turn. The shoot then becomes dormant through the first winter, in phase 4, while in phase 5, which starts in the spring, leaf initiation, leaf expansion and internode elongation occur simultaneously. In phase 6, which occurs in the late summer or autumn in temperate climates, the shoot apex produces a rosette of leaves (and occasionally flower initials in some varieties), while the apices in most of the axillary buds change from the vegetative to flowering condition, until the shoot again becomes apparently dormant in phase 7. During this phase the condition of dormancy is broken by winter cold, but elongation does not start until the spring, when the axillary buds produce short lateral shoots, which bear leaves, flowers and, finally, fruits (phase 8). The cycle is completed in phase 9, when most of the shoot dies after fruiting, except for a short length at the base, near ground-level, from which a replacement shoot has meanwhile grown, to repeat the phases and continue the cycle of annual fruiting in the following year.

The phases of growth thus provide meristems in the following series of different conditions, and it is because of this succession, and the occurrence of phases in which meristematic activities are separable, that the species is of such interest :

	Phase
Vegetative apex:	
Emphasis on leaf initiation	1
Emphasis on internode elongation	2
Emphasis on leaf expansion	3
Dormant	4
Initiation, elongation and expansion occur simultaneously	5
Flowering apex :	
Flower initiation	6
Breaking of dormancy	7
Flower expansion to fruiting	8
Senescence and death	9

Since these phases are observed to occur with great regularity at particular seasons of the year in temperate climates, it was assumed that the progression from phase to phase was mainly the result of seasonal changes in the environment, and this aspect has been investigated further. My colleague, Dr. I. H. Williams, has elucidated the main effects of environment on development of the raspberry plant in a series of elegant experiments in four simple growth rooms where temperature, day-length and light intensity were controlled[3,4]. Williams has shown that differences in the behaviour of the apical meristem are largely brought about by changes in temperature and day-length, but there is an additional factor, in some phases, of 'ripeness to proceed' to the next phase, since it seems necessary for shoots to remain for a minimum period in some phases before they can enter upon the next even though

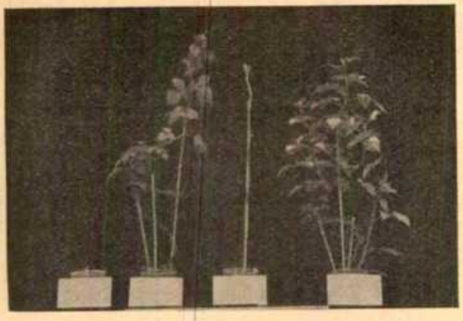


Fig. 2. Raspberry plants, all 32 weeks old, showing the effects of environmental factors on behaviour. Plants subjected to various combinations of 'summer', 'autumn' and 'winter' conditions in growth rooms show (left to right) a plant maintained in the rosette condition; one which has made continuous growth and is now 7 ft. high; a shoot in the winter dormant phase; and a plant with 'second-year' fruiting laterals in flower (left) and a new basal replacement shoot (right)

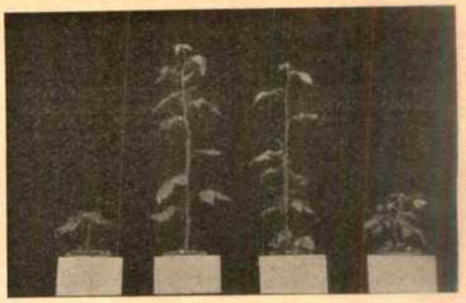


Fig. 4. Raspberry plants after 16 weeks in a growth room at 10° C. and 8 hr. day. Left to right: control plant with terminal rosette of leaves; plant treated with 1 μgm. gibberellic acid weekly from the outset; treated 1 μgm. weekly after rosette began to form; treated 1 μgm. weekly after rosette was fully formed. The shoot has continued to grow in the second and third plants, and recommenced growth from the rosette in the fourth

environmental conditions are conducive to that move.

Williams has also shown that the raspberry shoot can be maintained in some of the phases for far longer than the normal period, but that successive phases can also be telescoped by moving plants from one environment to another as soon as they are ripe for the next phase. Indeed, he has been able to reduce the time spent in each phase to such an extent that ripe fruits have been produced in several experiments little more than six months after the shoots had been initiated as buds on raspberry roots, thus reducing to a quarter the time which the complete cycle normally takes in Nature (Fig. 2).

It is thus quite feasible to affect the behaviour of this species by altering the nature of its physical environment, but work is now concentrating on methods of inducing shoots to pass to the next phase without changing the environment. The rosetted shoot (phase 3) has been chosen for this work, since it is at that time 'ripe to proceed' but is prevented from growing into a vigorously elongating leafy shoot by adverse weather conditions, which normally induce a period of dormancy in temperate climates. In most of the experiments elongating plants, grown at 18° C. and 12 hr. days, have been put into an environment with a lower temperature (10° C.) and shorter days (8 hr.), under which conditions they will normally form terminal rosettes of leaves within two or three weeks and thereafter remain in the rosetted condition for many months, slowly unfolding new leaves but with no elongation of the internodes (Fig. 3). Various chemicals have been applied to the stem apices, with outstanding results from the use of gibberellic acid, as might be expected from the effects which this remarkable growth-regulating compound has been shown to have on other species[5]. If elongating plants are put into this environment and are immediately given weekly treatments of 1–2 μgm. of gibberellic acid per plant, applied to the tip of the shoots with a micropipette, they continue to elongate steadily, unfolding new leaves (Fig. 4). On the other hand, if plants are allowed to form rosettes and are then given similar treatment they will recommence to elongate at once (Fig. 5). If the applications cease, the effect of the gibberellic acid wears off within a few weeks and the shoot once more rosettes, while re-introduction of the treatment a few weeks later causes elongation to recommence, with further leaf expansion, and so on. Thus, weekly applications of gibberellic acid at a low concentration will prevent raspberry shoots from rosetting, or will cause rosetted shoots to recommence elongation, under environmental conditions which would normally induce rosetting and maintain shoots indefinitely

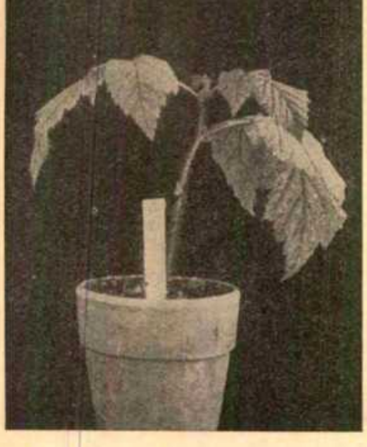


Fig. 3. Raspberry shoot showing a terminal rosette of leaves induced by putting a rapidly growing plant into a temperature of 10° C. and day-length of 8 hr.

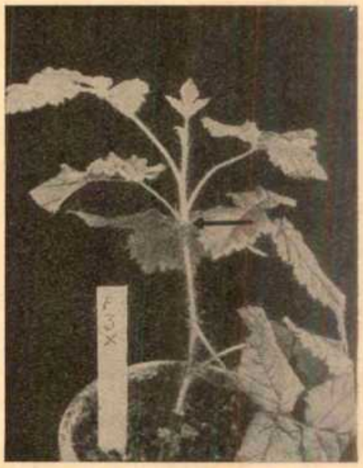


Fig. 5. Shoot recommencing to elongate from a terminal rosette (indicated by arrow) after being treated with gibberellic acid in an environment which would normally maintain the plant in the rosetted condition

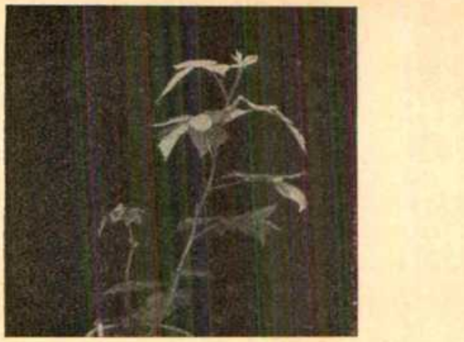


Fig. 6. Plant grown for six months at 10° C. and 8-hr. day. After forming a terminal rosette the original shoot (left) was treated with gibberellic acid, which caused it to recommence elongating and at the same time stimulated a basal shoot to grow (right) although that shoot was not treated at any time. When treatment of the left-hand shoot ceased after a few weeks it formed a new terminal rosette but the new shoot continued to elongate without rosetting

in that condition. Treatment with gibberellic acid, particularly after rosetting, also has the effect of stimulating the basal bud into growth, even though no acid is at any time applied to that bud or shoot, and there is a curious tendency for the new basal shoot to continue to elongate even after treatment with gibberellic acid has ceased and the original shoot has reverted to the rosetted condition (Fig. 6).

Heavier applications of gibberellic acid (for example, a single treatment with 200 μgm.) cause very rapid and abnormal elongation both of the rosetted apex and of the basal bud, which would not normally elongate until the following year, and the effects of such a single application persist for at least three months.

The importance of these results is that treatment with gibberellic acid changes the reaction of the plant to its environment, in this case causing a shoot to grow (that is, increase in length and leaf area) under weather conditions which would normally prevent it from elongating. By the use of appropriate dosages the growth made under the stimulus of gibberellic acid is quite normal and healthy.

Although the work on raspberry has little apparent application to general crop husbandry, it is not difficult to see the significance of these results. For various reasons such as risk of late frost or technical difficulties of cultivation, it is often necessary to delay the sowing or planting of crops, which make slow growth at first and may still be small when optimal growing conditions occur later in the season[6]. Earlier sowings may be useless in practice, since the young plants may fail to make appreciable growth under sub-optimal conditions of low temperatures or short days. However, if at this stage growth could be stimulated by chemical treatment under marginal weather conditions, but without causing the plant to initiate flower primordia, a larger plant might be produced by the beginning of the growing season, capable of taking full advantage of seasonal improvements in the weather. Crops might then make more total growth or might ripen earlier, or both.

The word 'marginal' is stressed. There is likely to be little profit in forcing plants to grow under dangerously sub-optimal conditions, and there might even be a risk of losing the crop altogether ; but the careful control of plant behaviour in response to certain marginal weather conditions might offer a technique of considerable practical value in agriculture, enabling the farmer for the first time to break the grip of the weather on his crops. The work will continue in this Department with raspberries and a few other species, but the purpose of this article is to suggest that it might be worth while to make similar investigations on the major world crop species in centres where facilities exist for that type of work.

I am grateful to my colleague, Miss J. M. Cook, for the use of some unpublished results of her experimental contribution to this work.

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STRUCTURE AND REACTIONS IN ORGANIC CHEMISTRY

THE KEKULÉ SYMPOSIUM

A SYMPOSIUM on Theoretical Organic Chemistry was held in London during September 15–17 in celebration of the centenary of the discovery by Kekulé of the quadrivalency of carbon. Organized by the Chemical Society on behalf of the Organic Chemistry Section of the International Union of Pure and Applied Chemistry, the meetings were devoted to invited lectures and papers on chemical binding and structure, nucleophilic reactions, and electrophilic and homolytic reactions. The proceedings will be published in full.

It is probably true to say that no single paper has had so fundamental and far-reaching an influence on the development of organic chemistry as has Kekulé's paper of 1858 on "The Constitution and Metamorphosis of Chemical Compounds and the Chemical Nature of Carbon" (*Annalen der Chemie*, **106**, 129 ; 1858). It was in this paper that Kekulé clearly recognized that carbon is tetravalent and that carbon atoms can link together. These two concepts produced order out of chaos, led to the confirmation of the principle of homology, to the idea of closed rings and, in 1865, to the structure of benzene itself. Modern structural organic chemistry had begun, and the decades that followed saw the very rapid development of the subject which, with advancing years, included natural products and synthetic compounds of greater and greater complexity within its understanding. It was fitting, too, that this symposium should be held in London, because in 1854 Kekulé was appointed as private assistant to J. Stenhouse at St. Bartholomew's Hospital, and it was while travelling on the upper deck of a Clapham omnibus on the return journey from a visit to Hugo Müller at Islington that he first conceived the basis of his now famous *Strukturtheorie*.

The symposium was formally opened by Prof. H. J. Emeléus (Cambridge), the president of the Chemical Society. Each of the three days opened with a lecture, which was followed by the reading of five papers. Sir Christopher Ingold (London), Prof. W. Doering (Yale) and Prof. R. Huisgen (Munich) acted as chairmen.

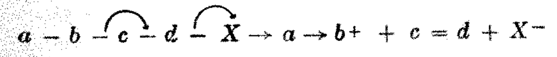
The symposium opened with a lecture by Prof. L. Pauling (Pasadena) on the nature of the double bond and of conjugated and aromatic molecules. He pointed out that, although the nature of the single bond is now well understood, there still remains some doubt about the best description of multiple bonds and of the structures of molecules in which these bonds are considered to play a part. Of the two ways of describing the double bond—first, as composed of a σ- and a π-bond, and secondly, as composed of two equivalent 'bent bonds', the second was preferred. "Bent bonds", it was maintained, "are best". The two descriptions are equivalent in the approximation in which the bond orbitals are *sp*-hybrids, but the inclusion of contributions from *d*, *f*, etc., orbitals to the bond orbitals results in concentration of the orbitals in the direction of the bond, and causes the two descriptions to differ significantly. In these circumstances, the 'bent bond' description was shown to afford superior interpretations of the observed magnitude of potential barriers to rotation about certain single bonds adjacent to multiple bonds, of the ratios between single, double and triple bond-lengths, and of observed bond-angles. Some implications of the 'bent bond' concept in considerations of the structure of aromatic compounds were also discussed.

A comparison of the results of the resonance and molecular-orbital theories when applied to the ground states of some π-electron systems was given by Prof. H. C. Longuet-Higgins (Cambridge). It was shown that the molecular-orbital theory is to be preferred in the treatment of molecules such as *cyclo*butadiene and diphenylene, containing unsaturated rings in which the number of π-electrons is not of the form $(4n + 2)$. The use of localization energies for predicting the reactivities of molecules in both heterolytic and homolytic reactions was also illustrated. Further work on the theory of aromatic character was described by Prof. D. P. Craig (London), in which the possibilities of π-electron delocalization of orbitals other than $p\pi$, such as $d\pi$ and $f\pi$, were considered. In this wider framework aromaticity can be of two distinct kinds. Apart from the normal, or 'homomorphic' aromaticity, which is characterized by the prime role of the aromatic sextet, a second kind, called 'heteromorphic' aromaticity, is expected to occur in cyclic systems of alternating $p\pi$- and $d\pi$-orbitals, and should show no special preference for a sextet over an octet. Some features of the six- and eight-membered cyclic phosphonitrilic halides are compatible with delocalization of this type, and there are indications of the wider occurrence of this kind of aromaticity. The problems involved in the synthesis of new structural types possessing aromatic character were discussed by Prof. W. Doering (Yale). The structures discussed included the tropylium ion $C_7H_7^+$, and its relatives, tropone and tropolone. Among neutral molecules, in the five-membered series fulvene, C_6H_6, has recently been obtained, and also probably fulvalene, $C_{10}H_8$, by an arduous removal of four hydrogen atoms from two molecules of *cyclo*pentadiene. In the seven-membered series heptafulvene, C_8H_8, has been obtained in solution as an unstable, deep-red compound, and heptafulvalene, $C_{14}H_{12}$, has been obtained as a violet-red crystalline substance.

Attempts to provide quantitative experimental results to support quantum-mechanical calculations on conjugated systems by Kistiakowsky's classic method of measurement of heats of hydrogenation were described by Prof. R. B. Turner (Houston). In the more recent experiments described, it has been possible to apply corrections for steric strain energies to the measured total stabilization energies. Such corrections were shown in some instances to be large and important. In the last paper of the first day, Prof. C. A. Coulson (Oxford) discussed the influence of steric deformation and consequent departures from exact planarity on the π-electron structure of conjugated and aromatic molecules. The several distinct situations which can arise, namely, rotation about a formally single bond, as in diphenyl, large polynuclear over-crowded hydrocarbons like dibenzophenanthrene, where the strain is distributed over the whole molecule, phenanthrene-type distortions in which hydrogen atoms are displaced out of the plane, and buckled rings such as hexachlorobenzene, were considered separately.

The second day of the symposium was opened by Sir Christopher Ingold (London), who delivered a lecture on "Nucleophilic Octahedral Substitution". The displacement of the ligand X as an anion from various cobaltic ions of the form $(\mathrm{Co\ en}_2AX)^+$ is typical of this class of reaction, in which the regular space-figure involved is an octahedron. The kinetic characteristics of these reactions point to the dominance of two mechanisms, analogous to the known organic-chemical mechanisms S_N1 and S_N2. The analogy extends fairly closely to the effects of substituent groups and of the nucleophilic capacity of the reagent on reactions by both mechanisms. The interpretation of the stereochemical results of these substitution reactions is complicated by the circumstance that the geometrical correlation between experimental result and molecular cause is less clear-cut in octahedral than in tetrahedral substitution. It appears that neither S_N1- nor S_N2-type octahedral substitutions by anions are stereochemically specific, although the latter show evidence of orientation, by the preserved ligands, caused principally by conjugative electron-displacement. However, octahedral substitutions of chloride ion by neutral water appear to proceed uniformly without stereochemical change. The theoretical implications of these findings and, in particular, of the differences between the neutral and anionic reagents, were discussed in detail.

Prof. J. D. Roberts (Pasadena) discussed the results of a kinetic investigation into the hydrolysis of diaryliodonium salts to phenols and aryl iodides. The reaction was studied under conditions likely to give rise to an S_N1 mechanism, since under these conditions phenyl cations might be expected to be produced. However, the rather unexpected results which were obtained on the effects of substituent groups on the distribution of products, and the catalytic effects of oxygen, acids and copper salts were taken as an indication that the complete reaction, which can be described as a nucleophilic substitution, involves the intermediate formation of solvent-caged free radicals. Recent research on the phenomena of fragmentation in solvolytic reactions was described by Prof. C. A. Grob (Basle). The heterolysis of a bond to an electron-acquiring group X in a system a–b–c–d–X may lead to the heterolysis of the bond between b and c, resulting in fragmentation (β-cleavage) of the molecule, as well as to the well-understood processes of substitution, elimination and rearrangement :



$$a - b - c - d - X \rightarrow a \rightarrow b^{+} + c = d + X^{-}$$

This can occur if a is an electron-donating group, and is particularly prevalent in γ-amino-halides, where a is $-NR_2$. Two unimolecular mechanisms for the fragmentation have been found to be operative, namely, a one-step process in which ionization of X and cleavage of the C_β—C_γ bond are synchronous, and a two-step mechanism in which the rate-determining ionization is followed by a faster product-determining step, which can lead to fragmentation or to other processes.

A review of recent progress in conformational analysis was given by Prof. D. H. R. Barton (London). The subjects discussed included the rearrangement of diaxial products of addition reactions to the *cyclo*hexene system to the corresponding diequatorial isomers, which was illustrated by new rearrangement reactions of halohydrin esters. After a review, in conformational terms, of the behaviour of carbanions, Prof. Barton concluded his paper with a discussion of long-range group effects in large saturated molecules, such as steroid and other systems. It was concluded that these effects are transmitted by the successive distortion of valence angles. The effect is referred to as 'conformational transmission'. The S_N2 mechanism of substitution at aromatic and other unsaturated centres was discussed in a paper by Dr. J. F. Bunnett (Providence). It was shown that in contrast to the synchronous S_N2 mechanism of substitution at a saturated carbon atom, the S_N2 mechanism in these examples involves the formation of metastable intermediate complexes. Often the bond to the incoming group is completed before the bond to the outgoing group starts to be broken. It is possible that the strictly synchronous S_N2 mechanism is unique for displacements at saturated carbon. The role of 'benzyne' intermediates in rearrangements observed during nucleophilic aromatic substitutions with alkali amides or organolithium compounds was reviewed by Prof. R. Huisgen (Munich). Recent investigations were described which establish the mechanism more firmly and resolve some of the discrepancies attendant upon it.

Prof. M. J. S. Dewar (London) opened the last day of the symposium with a lecture on "Rearrangements in Aromatic Compounds". These rearrangements were classified and their possible mechanisms, including the intramolecular mechanism involving the formation of π-complexes, were discussed. New experimental work on the rearrangements of N-bromoacylanilide derivatives, and the acid-catalysed rearrangements of alkyl aryl ethers, was described. Both these rearrangements appear to be intermolecular. The mechanism of the benzidine and related rearrangements was discussed in the light of known experimental data, and the intramolecular mechanism previously suggested by Prof. Dewar was shown to be not inconsistent with the recently discovered dependence of the rate of rearrangement on the square of the concentration of the acid catalyst.

Researches on the mechanism of nitration were reviewed by Prof. E. D. Hughes (London). Although the mechanism of nitration via the nitronium ion is very common, the paper included a discussion of nitration via nitrosation, and C-nitration via N-nitration and rearrangement. Work on O-nitration, which also proceeds via the nitronium ion, was discussed. Some recent studies of reactivity and orientation in aromatic halogen substitution reactions were described by Dr. P. B. D. de la Mare (London). Halogenation can take place either directly, by the molecular reagent, or with the intermediate formation of chlorine or bromine cations, or their hydrated forms. The conclusion that the inductive effects of substituent groups are less important in determining orientation in substitution by molecular than by charged species was reached from a consideration of recent work on halogenation, and was discussed in terms of the transition states for the two modes of substitution.

Recent evidence for the operation of quasi-heterolytic mechanisms for reactions in the gas phase was presented by Dr. A. Maccoll (London). The reactions considered, for which such mechanisms appear to be correct, were the unimolecular dehydrohalogenation of alkyl halides and olefin elimination from esters. The first group shows close similarities to the S_N1 and $E1$, and the second to the $E2$, mechanisms for reactions in solution. The possibility of acid catalysis in the gas phase was discussed with reference to the elimination of olefins from alcohols catalysed by hydrogen halides. The remaining two papers dealt with homolytic reactions. Prof. D. H. Hey (London) described recent work on reactions of aroyl peroxides with naphthalene. The formation of arylnaphthalenes, naphthyl esters and dinaphthyls, and the proportions in which the various isomers of these substances were formed, were rationalized in terms of the various substitution and hydrogen-abstraction reactions which may occur with radicals of different polar and steric requirements. Recent measurements of the methyl (alkyl) affinities of various aromatic compounds and olefins were presented and discussed by Prof. M. Szwarc (Syracuse). The relationship between the experimental results and theoretical calculations of localization energies was shown to be consistent with a model of the transition state for attack by alkyl radicals in which the repulsion between the radical and the molecule and the attraction between the same radical and the 'residual' molecule (that is, a hypothetical molecule in which an electron is localized on one of the carbon centres) are balanced.

On the evening of September 15 those attending the symposium were invited by the University of London to a reception by the Vice-Chancellor (Dr. C. F. Harris) at the Senate House. On the following evening the Kekulé Symposium dinner was held at the Connaught Rooms, at which the speakers were Prof. H. J. Emeléus (president of the Chemical Society), Prof. P. E. Verkade (president of the Section of Organic Chemistry of the International Union of Pure and Applied Chemistry) and Prof. R. Huisgen.

D. H. HEY
G. H. WILLIAMS

OBITUARIES

Prof. K. S. Lashley, For.Mem.R.S.

KARL SPENCER LASHLEY was born in West Virginia on June 7, 1890. He died in Paris in August 1958.

Whatever may turn out to be the correct detailed story of nerve conduction and the localization of mental functions in the brain, it is safe to say that Lashley's work will always stand distinguished for the brilliance of his experimental attack, for the originality and sweep of his ideas, and for the incisiveness and clarity of his exposition.

Lashley received his scientific training, about equally in zoology and in psychology, at the Universities of West Virginia, Pittsburgh and Johns Hopkins. He became a professor of psychology first in the University of Minnesota and then at Chicago. In 1937 he was appointed research professor of neurophysiology at Harvard, and five years later he also became director of the Yerkes Laboratories of Primate Biology at Grange Park, Florida. It was in Florida, in his home there, working among his chimpanzees, with his carefully chosen band of students, and often piloting his small sailing boat, mostly alone in coastal waters, that he spent, probably, the happiest years of his life.

Some of Lashley's early work was carried out in conjunction first with H. S. Jennings, and later with the behaviourist, J. B. Watson. But he never, all his life, for long allowed himself to stay tied to anybody else, or to theories other than his own. Perhaps it was their unconventional character, and the fact that they were rebelling against respectable and established opinions of their day, which attracted him in turn to behaviourism, to Pavlovian conditioned reflex theory; and then, by what seemed rather like a complete somersault, to *Gestalt* psychology, and even to some of the more romantic aspects of Freudism. All of these had some influence with him; none of them carried him away.

From 1912, when he published his first paper—on visual discrimination of size and form in the albino rat—to the middle 1920's, he was busy with many and varied experimental investigations in animal behaviour. These moved more and more definitely towards what he called "studies of cerebral function in learning". In 1929 he published his famous book "Brain Mechanisms and Intelligence", and this was very quickly recognized as of outstanding importance. Nearly everybody who writes now of this volume directs attention to Lashley's two principles of brain activity, which he called "Equipotentiality" and "Mass Action". Taken together and in a broad sense, these principles, and particularly the abundant, detailed and original evidence upon which they were based, expressed and demonstrated the view that there could be considerable loss or injury to brain tissues and still the behaviour functions subserved by the areas concerned could be carried on, though sometimes in ways new and different compared with those which had been learned. What particularly marked Lashley's neurophysiological approach was its loyalty, at the same time, to the highest and most exact standards of behaviour experimentation. Plenty of people have shown that it is easy to be scientifically exacting on one side, and little but dogmatic on the other; Lashley accepted and used the same rigour of research on both.

Until he moved to Florida and the chimpanzee colony, most of Lashley's experimental work had been carried out with rats. But with the opportunities which he now had, he began to devote more attention to studies of the neurophysiological foundations of some of the higher and more complex mental functions. In a broad sense, his views about the areal and patterned character of brain activities remained unchanged. He continued to publish a number of splendid papers, and he inspired notable experimental work by his students. But he ran into a period of prolonged ill-health. In the summer of this year he seemed to be better, and he set out upon one more journey to Great Britain and to France. He had been elected a Foreign Member of the Royal Society in 1951. On July 28 he signed the Charter book of the Society, and then continued his planned trip to France. There, in Paris, about a fortnight later, he died.

Lashley, superbly intelligent himself, liked people to be, in his judgment, intelligent. He very quickly made up his mind about this, and anybody who met him, though maybe only for a short time, and was accepted by him as up to the mark, could never forget his brilliant, rather wayward, and most lively habit of mind. Though he was a fine and patient experimenter, he was no laboratory recluse. High among more general interests were music—he was good with a violin—and sailing. Sometimes he said that he would have liked best of all to sail lonely voyages across the widest seas in some small boat. When he came to Europe he always preferred, if he could do so, to travel in a little tramp steamer; he disdained the luxury liner. Life to him was an adventure, a continuing opportunity for original exploration, whether in action or by thought, and if it could be very clear that the responsibility for whatever he found was wholly his own, that was all the better.

F. C. BARTLETT

The Rev. T. N. Burke-Gaffney, S.J.

WITH the death of Thomas Noel Burke-Gaffney on September 14, Australian seismology has suffered an almost irreplaceable loss.

Father Burke-Gaffney became director of the Riverview College Observatory in 1952 when the former director, Father D. J. K. O'Connell, was appointed director of the Vatican Astronomical Observatory. He occupied the post with distinction, and more than maintained the reputation which Riverview has held for fifty years as one of the world's first-class seismological observatories.

He was that rare type of seismologist to whom the records of each earthquake take on the form of a distinct personality. Through this faculty, he developed an insight into the reading of seismic records the like of which we may not see again in Australia. He was devoted to his work, and few outside the ranks of seismologists in Sydney and a small number of his close colleagues know of the extent to which he helped, beyond his strength, young seismologists in many parts of Australia to an understanding of the intricacies of seismic recording.

He played a valued part in Australia's International Geophysical Year work as convener of the

National Subcommittee on Seismology, and was for several years a member of the Council of the Royal Society of New South Wales. In these and related offices he gave of his best.

His published work includes seven papers on seismology, the last of which appeared in the *Australian Journal of Physics* shortly after his death. The papers were concerned with the seismicity of Australia, the problem of detecting *S* waves in the Earth's inner core, special phases from New Zealand earthquakes, and seismic aspects of nuclear explosions. The last work has attracted world-wide attention.

Father Burke-Gaffney was born in Dublin on December 26, 1893, and entered the Jesuit order in 1913. He took up residence in Australia in 1928 as senior science master at St. Ignatius's College, Riverview, Sydney, and in 1946 became assistant director of the College Observatory. He lived austerely, and was one of Australia's most unassuming scientists and a man of quiet, gentle dignity. Few outside his College friends and his seismological colleagues got to know him well; but those of us who did, knew him as a charming liberal-minded man graced with a delightful humour and who dedicated himself to his work.

K. E. BULLEN

NEWS and VIEWS

Nobel Prize for Medicine and Physiology: Prof. J. Lederberg; Prof. G. W. Beadle and Dr. E. L. Tatum

THE recent award of the Nobel Prize for Medicine and Physiology for 1958 to Prof. Joshua Lederberg, and jointly to Prof. G. W. Beadle and Dr. E. L. Tatum, is a signal acknowledgment of the great advances which have been made in knowledge of the genetics of micro-organisms in recent years, and of the importance of this knowledge to an understanding of living processes in general.

The main contribution of Beadle, the geneticist, in collaboration with Tatum, the chemist, was to show first, in 1941, that mutations induced by irradiation in the mould *Neurospora crassa* resulted in inability to synthesize specific chemical nutrients which the organism needed for growth. Genetic crosses between the mutant and parental strains invariably showed that each mutant strain, having a single specific requirement, differed from the parental strain by alteration of only a single gene. Thus single genes appeared to control single biochemical reactions and, by inference, the formation of single enzymes. This first successful attempt to relate genetic and biochemical function experimentally gave birth to the stimulating 'one gene, one enzyme' hypothesis and initiated the expanding field of biochemical genetics. In further studies Beadle and Tatum traced the synthetic defects of some of their mutant strains to inability to perform various specific intermediate steps in the chain of processes leading to formation of such required end-products as amino-acids or vitamins of the B group. By wedding experiments with such mutants to inspired guess-work concerning presumptive precursors in biosynthesis they, and many subsequent workers, have built up a formidable mass of knowledge about intermediary metabolism.

Tatum (1944–46) extended these *Neurospora* studies to bacteria. As a result, a considerable stock of nutritionally defective mutant strains of *Escherichia coli* were developed. Lederberg, who was working with Tatum at this time, conceived the idea that these mutants might be used to provide a definitive test of the occurrence of sexuality in bacteria. The experiments were immediately successful and were first reported jointly by Lederberg and Tatum in 1946 in *Nature*. Subsequent studies by Lederberg proved the existence of a linear linkage between many of the genes of *Escherichia coli*, thus showing, for the first time, that bacteria are fundamentally similar to other types of cell in their genetic and biochemical constitution. These studies, which then appeared to S. E. Luria "to be among the most fundamental advances in the whole history of bacterial science", served as the starting point for many far-reaching discoveries in the field of bacterial genetics which Lederberg has ever since continued to fertilize with new ideas and techniques. In 1952, he and Dr. N. D. Zinder showed that certain bacterial viruses (bacteriophages) could act as vectors of small fragments of bacterial chromosome from one cell to another so that recombinant types arose: development of this discovery, especially by Dr. M. Demerec and his colleagues, has provided important new concepts about the fine structure and function of the gene. In 1953, Lederberg and his wife, Dr. Esther M. Lederberg, simultaneously with Dr. E. Wollman of the Pasteur Institute, Paris, first proved that the genetic material of a bacterial virus of low virulence might attach itself to a specific site on the bacterial chromosome and thereafter be propagated indefinitely among the progeny of the host cell as though it were part of its normal hereditary constitution. Lederberg and his wife also developed a simple but elegant technique, known as 'replica plating', which, in addition to its wide applicability as a laboratory tool, was used by them to demonstrate directly, for the first time, that bacterial mutations, such as resistance to certain antibiotics or viruses, arose spontaneously and not in response to environmental stimuli.

Royal Society: Medal Awards

THE following awards of medals have been made by the President and the Council of the Royal Society: *Copley Medal* to Prof. J. E. Littlewood, lately Rouse Ball professor of mathematics in the University of Cambridge, for his distinguished contributions to many branches of analysis, including Tauberian theory, the Riemann zeta function, and non-linear differential equations; *Rumford Medal* to Sir Thomas Merton, formerly professor of spectroscopy in the University of Oxford, for his distinguished researches in spectroscopy and optics; *Davy Medal* to Prof. R. G. W. Norrish, professor of physical chemistry in the University of Cambridge, for his distinguished work in chemical kinetics, especially in photochemistry; *Darwin Medal* to Sir Gavin de Beer, director of the British Museum (Natural History), for his distinguished contributions to evolutionary biology; *Sylvester Medal* to Prof. M. H. A. Newman, Fielden professor of mathematics in the University of Manchester, for his distinguished contributions to combinatory topology, Boolean algebras and mathematical logic; *Hughes Medal* to

Prof. E. N. da C. Andrade, emeritus professor of physics in the University of London, for his distinguished contributions to many branches of classical physics.

The Royal Society of Edinburgh

The following officers and members of Council were elected at a meeting of the Royal Society of Edinburgh, held on October 27: *President*, Prof. J. Norman Davidson; *Vice-Presidents*, Prof. A. C. Aitken, Dr. J. E. Richey, Prof. D. Whitteridge, A. W. Young, Prof. E. L. Hirst, Prof. J. R. Matthews; *General Secretary*, Prof. Norman Feather; *Secretaries to Ordinary Meetings*, Dr. A. W. Greenwood and Dr. Mowbray Ritchie; *Treasurer*, Dr. J. R. Peddie; *Curator of Library and Museum*, Dr. Douglas Guthrie; *Ordinary Members of Council*, Dr. J. A. Macdonald, Dr. Robert Schlapp, Dr. J. B. Tait, Prof. G. M. Wyburn, Prof. R. A. Rankin, Prof. A. E. Ritchie, Prof. W. M. Smart, Prof. V. C. Wynne-Edwards, Prof. E. G. Cullwick, Prof. G. Pontecorvo, Prof. M. M. Swann, Prof. T. S. Westoll.

Zoological Society of London: Dr. D. Morris

The Zoological Society of London has appointed a new curator of mammals, Dr. Desmond Morris, who will commence his duties on January 1, 1959. Dr. Morris graduated at the University of Birmingham and then moved to Oxford to study for a doctorate on animal behaviour under Dr. N. Tinbergen, and remained to expand his studies with several years of postdoctoral research. His work was mainly concerned with the analysis of aggressive, sexual, parental and social behaviour patterns in various vertebrate species. He published numerous papers on these subjects, including several monographs, in which attempts were made to unravel the whole social structure of particular species. Other papers dealt with modifications and extensions of certain behaviour concepts, such as displacement activities. His most important studies were in the field of animal communication, where he introduced the concept of 'typical intensity', and focused attention on the importance of autonomic signals in the evolution of animal language. Three years ago, Dr. Morris left Oxford to take up the post of head of the Granada Television and Film Unit at the Zoological Gardens, London, and has since devised and presented more than a hundred television programmes about animals. Working on these programmes inside the Zoo has given him wide experience of the Zoological Society's collection of mammals. This experience, combined with his knowledge of animal behaviour problems in general, will prove invaluable when he takes up his new appointment next January.

A New Higher Technological Award

The National Council for Technological Awards has announced that in order to encourage qualified men and women to undertake further study beyond the level of the diploma in technology (Dip.Tech.) and to carry out original investigations, it has decided to create a higher award. It is intended that this award shall be a mark of distinction granted to a student who has proved his ability by completing a substantial programme of work demanding the application of his knowledge to the solution of a problem of value to industry. The Council will establish a new college, to be known as the College of Technologists, and the new award will take the form of membership of this College (M.C.T.). To qualify for this award a student must undertake a programme of work to be carried out jointly in industry and at a technical college. This programme may be concerned with any technological aspect of industrial activity, such as research, development, design, production or market investigation. The Council believes that to carry out successfully post-diploma work of this character, students must remain in contact with industry or with commercial laboratories. A candidate must apply for registration to the College of Technologists through the technical college at which he will study. The programme offered should be related to the student's experience in industry and have the approval of his employer. It should be likely to result in a useful contribution to technological knowledge and require industrial experience and academic study extending over a substantial period; a three-year period of work is envisaged, provided a high proportion of a student's time can be devoted to it. The work must be supervised by a member of the staff of the technical college at which it is undertaken and by a staff member of the industrial organization concerned. The technical college concerned will be responsible for the examination of candidates, subject to any general arrangements, including the approval of external examiners, which may be prescribed by the College of Technologists.

Exchange of Scientific Information

Asked on November 5 about reciprocity between Great Britain and the United States of America and the U.S.S.R. for the exchange of scientific and educational and cultural information and personnel, Mr. Ian Harvey said there was complete reciprocity between Great Britain and the United States. The Soviet Government had refused a request from the British Government in April for talks on various aspects of freedom of information with a view of similar reciprocity between Britain and the U.S.S.R. Within a more limited sphere, however, reciprocal exchanges in the educational, cultural and scientific fields were arranged by the Soviet Relations Committee of the British Council, set up for this purpose in 1955 at the request of the British Government. The scale of these arrangements has increased in the past six months and reciprocal exchanges of scientific publications have recently been intensified.

Science Teachers and Laboratories

In the House of Commons on November 6, the Minister of Education, Mr. Geoffrey Lloyd, stated that in March 1957 the heads of schools reported that they had about 500 vacancies for graduate teachers of science and mathematics, and that about 400 posts were unsatisfactorily filled. In a written answer, he stated that no arrangement has been made by his Department with the Industrial Fund for the Advancement of Science Education in Schools. The latter directs its attention to the independent and direct grant schools, because responsibility for the maintained schools rests with the local education authorities and his Department. The capital cost of new science laboratories being provided each year at maintained schools is now about £2 million.

Nuclear Installations (Licensing and Insurance) Bill

The intention of the Nuclear Installations (Licensing and Insurance) Bill, which has recently been published, is to ensure that nuclear reactors on land are made effectively subject to control in the interests of safety and that their owners make adequate provision for the payment of compensation should the need arise. The Government's intention to introduce legislation on these lines was announced in the House of Commons on February 10 by the Parliamentary Secretary to the Minister of Power. The operation of a nuclear reactor will require a licence from the Minister of Power (in Scotland the Secretary of State), and every licensee will have to pay compensation for any damage to property or personal injury from radioactive contamination even if it is due to an unavoidable accident, except to the extent that the claimant has been guilty of contributory negligence. The licensee will be required to insure his liability or show that he has adequate liquid assets. The liability is limited to £5 million in respect of any one incident. In the highly unlikely event of an incident causing more than £5 million worth of damage, special measures would be needed, and claims will be dealt with as Parliament determines. Since certain types of injury from radiation may become apparent only after a long time, the Bill provides that damages may be claimed up to ten years after the incident concerned. The U.K. Atomic Energy Authority already has a similar liability to that proposed in the Bill but it is not limited in amount; the Bill contains provision to extend the Authority's present liability to cover nuclear fuel in the course of carriage. The insurance market has informed the Government that it is ready to provide the necessary cover. Questions about premiums are a matter for the insurance market and the owners of reactors.

European Nuclear Energy Agency

In a pamphlet, "European Nuclear Energy Agency—Structure and Functions—First Joint Undertakings" (pp. 12. Paris: Organization for European Economic Co-operation, 1958), the Organization for European Economic Co-operation has issued what is largely a popular and illustrated version of the first report of the Steering Committee for Nuclear Energy. There are included some accounts of the organization of the Agency and the way in which it seeks to co-ordinate European scientific and technical activity in this field and to provide an overall view of research and investment programmes in nuclear energy in Europe, as a step towards harmonizing these programmes and avoiding duplication. Some account is also given of the stage reached in the construction of the nuclear study centre at Mol, where the small-scale joint plant for treating fuels from different reactors is to be built, of the boiling water reactor built at Halden by the Norwegian Institute for Atomic Energy and other projects of Eurochemie. There is also a map showing nuclear installations in member countries and a brief bibliography.

Civil Service Commissioners: Report for 1957–58

The ninety-second annual report of the Civil Service Commissioners, covering the period April 1, 1957–March 31, 1958 (pp. 32. London: H.M. Stationery Office, 1958. 2*s.* net), again refers to difficulties in recruitment and failure to meet all requirements; in most of the main classes of the Civil Service there were more vacancies than suitable candidates. During the year, 111,702 candidates were dealt with, compared with 112,590 in the previous year, but the number of successful candidates rose from 11,606 to 13,057 and the quality of applicants for the administrative class improved. There were thirty-nine successful candidates for forty vacancies, and it appears that the measures taken in recent years to make the work of the administrative class better known to university students have yielded results. The shortage of young trained scientists continued to affect recruitment to the scientific officer grade and more than half the vacancies advertised remained unfilled, although in the senior scientific officer competition most of the vacancies declared by departments were filled. Sixteen candidates of high promise were offered fellowships as a result of the Research Fellowship Competition, and, as a new departure, information about the 1958 Fellowship Competition was sent to British nationals at present holding Canadian and United States Fellowships. About seventy were willing to attend interviews which took place in Ottawa and Washington. Only thirty-six out of sixty-five declared vacancies for patent examiners were filled, and there was a decrease in applicants for vacancies in the engineering and technical classes. Recruitment of candidates with good scientific and technical qualifications into the Factory Inspectorate remained difficult. The continued lack of well-qualified young entrants for the engineering posts causes concern as to the future leadership in this field.

National Science Foundation Grants for Undergraduate Research

The U.S. National Science Foundation has announced plans to make a limited number of grants to colleges, universities and non-profit-making research institutions to provide, on an experimental basis, opportunities for undergraduates reading for degrees in the physical, biological, mathematical and engineering sciences to participate in research projects conducted by experienced scientific investigators. This scheme may operate either during the academic year or during the summer. Approximately 1,000 undergraduates at about one hundred institutions in the United States will be able to participate in these laboratory and field programmes which will afford them an opportunity to become acquainted with the nature and methods of research in progressively more independent roles. The Foundation will provide grants up to a maximum of 400 hr. per student. Expendable supplies and secretarial and administrative expenses directly attributable to this student training will also receive support.

Talanta: a Journal of Analytical Chemistry

The first issue of a new journal, *Talanta* (1, Nos. 1/2; July 1958. Pp. 196. Published bimonthly. Subscription (including postage): 17 dollars a volume (Great Britain, 120*s.*); for subscribers certifying that the journal is for their own personal use, 15 dollars (Great Britain, 105*s.*). New York and London: Pergamon Press, 1958), has now been published, with Dr. C. L. Wilson, of the Queen's University, Belfast, as editor-in-chief, regional editors in the United States, Czechoslovakia and Japan, and an advisory board of chemists eminent in the field of analytical chemistry. The editors hope to expedite the publication of the results of research by publishing papers within three to four months of acceptance and short communications within thirty to sixty days. Papers can be submitted in English, French or German. The present double issue contains twenty-one research papers, followed by short communications, book reviews, notices and lists of books and papers received.

Forum

A NEW educational journal has recently been launched with the view of discussing new trends in education with the appropriate title of *Forum*, and under the joint editorship of two lecturers in education at the University of Leicester, R. Pedley and B. Simon. Particularly concerned with the efforts to abolish the tripartite system of education in England and Wales, the first issue contains details of the present stage of the London plan to reorganize its secondary education in a system of comprehensive schools. There is also an account of the early stages of the Leicestershire experiment to eliminate the 'eleven-plus' examination without bringing all children within a single comprehensive school. These will be followed in future issues by articles describing changes in other areas of Britain where some form of comprehensive education is taking place. The journal is also concerned with the efforts now being made in many junior schools to modify rigid streaming and with new developments in the secondary modern schools. There is also a symposium on "Science Teaching in the Nuclear Age" and an article by Dr. Robin Pedley assessing the educational programmes of the political parties. Provided that future issues of the journal will remain as free from political bias as the first, *Forum* should provide a valuable means of communicating new thoughts and developments in the realm of secondary education. Whether this courageous experiment can survive at its present price (3*s*. for single issues or 8*s*. 6*d*. for three issues in one year) must be a cause for concern. The journal is published from 71 Clarendon Park Road, Leicester.

Science in Six American States

A REPORT recently issued by the U.S. National Science Foundation, entitled "Scientific Activities in Six State Governments", summarizes the findings of a survey conducted in 1954 to determine expenditure and man-power involved in scientific activities in California, Connecticut, New Mexico, New York, North Carolina and Wisconsin. The study covered only State-supported activities, including research and development, collection of data, dissemination of scientific information, training of scientific man-power, and testing and standardization. Of the total expenditure of 68·9 million dollars reported, 57 million dollars were spent on research and development, and of the total 4,335 man-years, 3,831 were similarly devoted. Scientific activities in State universities and agricultural experimental stations accounted for just less than 70 per cent of the totals in both dollars and man-years. The proportion devoted to research and development was similar in all six States, and health, education, welfare, research development and public works accounted for 80 per cent of both funds and man-years. In all six States, the business, labour and vocational licensing agencies and the State universities tended to rely more heavily on Federal funds for their programmes of scientific activity than did other groups of agencies, and this is attributed directly to the high level of Federal participation in the employment security functions of State governments. Some reference is made to the character of State organization in the conduct of research and development, to interdepartmental machinery for co-ordinating programmes, as well as to the inter-State and Federal influence of such co-ordination.

Birds and Mammals of Canada

FOLLOWING many requests from visitors to the Museum, the Department of Northern Affairs and National Resources of the National Museum of Canada has published two attractive booklets describing many of the native birds and mammals. The first ("Quelques Oiseaux du Canada." Pp. 48. (14 planches.) Ottawa: Queen's Printer, 1957. 35 cents), written in French by W. E. Godfrey, describes the typical characteristics of a bird, the distribution and numbers of birds throughout Canada, song, territory and breeding cycles, migration routes, food and the relation of birds to man. This is supported by details of some of the better-known and less well-known birds of Canada. The second ("Canadian Mammals." Pp. 81. Ottawa: Queen's Printer, 1958. 50 cents), written in English by A. W. Cameron, describes most of the bigger mammals such as the harp seal, the finback, white whale and blackfish, as well as the smaller mammals like the cinereous shrew and the star-nosed mole. Each account includes details of the anatomy, ecology and breeding behaviours of the mammal as well as a clear and attractive black-and-white drawing by John Crosby. The birds have been similarly illustrated by the same artist.

Coastal Erosion

ONE of the principal preoccupations of students of coastal erosion is the way in which beach material moves under the influence of waves and currents. Until recently, it has not been possible to obtain direct evidence. In an article in the *Geographical Journal* (124, part 2, 210; June 1958) a method of marking pebbles with the radioactive isotope barium-140 – lanthanum-140 is described. It is possible, by searching the sea bed and beach with Geiger counters, to trace the movement of the marked pebbles. This has been done at Scolt Head, and the present paper, by C. Kidson, A. P. Carr and D. B. Smith, gives an account of its application to Orford Ness, the shingle spit at the mouth of the River Ore in Suffolk. During a period of six weeks a large number of contacts was obtained, and it was shown that beach material moves along shore under almost all conditions and in more than one direction. The direction of movement is principally determined by the winds prevailing at the time, and the general direction of longshore drift is that developed under the influence of the dominant wind. It was also shown that river mouths, even where flood and ebb tides are strong, do not form barriers to the movement of beach material.

Galactic Rotation

MORE than twenty years ago Plaskett and Pearce gave an authoritative discussion of the rotation of the galactic system, using material referring mostly to the northern section of the Milky Way and to distances less than one kiloparsec. During the past six years the lack of observations from the southern hemisphere has been remedied at the Radcliffe Observatory, Pretoria, where 350 velocities of early-type stars have been obtained. A new analysis of galactic rotation has been made by M. W. Feast and A. D. Thackeray, and their results have now been published (*Monthly*

Notices of the Royal Astronomical Society, 118, 125, 1958). Their work was based on a selection of the available data, including only the more distant stars, for which the velocities should show galactic rotation effects. The rotation is usually described by the Oort constant A; the value of A has been the subject of some controversy. Analysing their data in several ways, Feast and Thackeray obtain for A the mean value 17·5 ± 1·5 km./sec./kiloparsec. The new results do not support the lower values of A obtained in some earlier determinations. Two partly independent methods were used to derive a value of the distance from the Sun to the galactic centre; the most probable value is 8·9 kiloparsecs. A value of 0·5 for the ratio of the axes of the velocity ellipsoid appears to be appropriate for distant B-type stars. The final section of the paper by Feast and Thackeray is devoted to a discussion of the variation of the angular velocity $\omega(R)$ of the Galaxy as a function of the distance R from the galactic centre. The results are in general agreement with the curve derived from Schmidt's model of the Galaxy, itself based on 21-cm. radio observations. $\omega''(R)$ definitely appears to be positive rather than negative. A negative value, obtained in some earlier investigations, is very unlikely on general dynamical grounds.

Australian Biochemical Society

THE Australian Biochemical Society held its third annual general meeting in the Medical School, University of Adelaide, during August 18–20. At this meeting fifty-three papers were presented, and the second annual lecture of the Society was given by Mr. Hedley Marston, on "The Biochemical Function of Cobalt". The present membership is 280, and this year's president is Prof. R. K. Morton, of the Waite Institute, Adelaide. The honorary secretary is Dr. F. D. Collins, Department of Biochemistry, University of Melbourne.

Welsh Soils Discussion Group

UNDER the auspices of the Welsh Plant Breeding Station and the Departments of Agricultural Chemistry, Geography and Geology in the University College of Wales, Aberystwyth, a Soils Discussion Group has been formed, which held its first meeting on October 29. Some of the members of the Group are members of the British Society of Soil Science, which has recently lent its support to the formation of local groups to concentrate on soil studies in their local areas. Some thirty members attended the first meeting, including Dr. Alex Muir, director of the Soil Survey of England and Wales, and some members of the staff of the Departments of Agricultural Chemistry at the University College of North Wales, Bangor, of the Nature Conservancy (North Wales), of the Forestry Commission (Aberystwyth) and of the National Agricultural Advisory Service (Trawscoed). The first meeting was addressed by Dr. Nicholas Rast (Geology Department, Aberystwyth) on "Geochemistry in the Service of the Soil". The second meeting of the Group will be held in Aberystwyth at the Department of Geography on February 4, when Mr. James A. Taylor (Department of Geography) will lecture on "Slope, Climate and Soil". A third meeting will be held on April 22, when Dr. Rice Williams (Trawscoed) will introduce the subject "The Soils of the Aberystwyth Area". Further information can be obtained from J. A. Taylor, Department of Geography, University College of Wales, Aberystwyth.

U.S. National Research Council Conference on Fracture

THE National Academy of Sciences – National Research Council is organizing a seminar on "The Atomic Mechanisms of Fracture" to be held in Cambridge, Massachusetts, during April 12–14, 1959, to discuss the following topics: theoretical aspects of fracture; cleavage; crystalline and non-crystalline fracture; fatigue and ductile fracture; high-temperature fracture. The conference is being sponsored jointly by the National Science Foundation, Office of Naval Research, Air Force Office of Scientific Research, and the National Academy of Sciences – National Research Council. Further information may be obtained from Dr. B. L. Averbach, chairman, or Dr. D. K. Felbeck, secretary, Conference on Fracture, National Academy of Sciences – National Research Council, Washington, D.C.

Announcements

DR. M. L. M. SALGADO, soil chemist and acting director, has been appointed permanent director of the Coconut Research Institute of Ceylon.

THE following were recently elected to office in the Mineralogical Society: *President*, Prof. C. E. Tilley; *Vice-Presidents*, Prof. L. R. Wager and Dr. A. K. Wells; *Treasurer*, Prof. J. H. Taylor; *General Secretary*, Dr. G. F. Claringbull; *Foreign Secretary*, Dr. L. J. Spencer; *Editors of the Journal and Abstracts*, Dr. M. H. Hey and Dr. N. F. M. Henry.

THE Geological Society of London has announced the award of R. H. Worth Prizes as follows: to Mr. E. W. J. Moore, in recognition of his work on the goniatite succession of the Carboniferous rocks of the north of England and Ireland; and to Mr. C. W. Wright, in recognition of his researches on the stratigraphy and faunas of the English Cretaceous rocks, and especially on the Cretaceous Ammonoidea.

AN informal discussion on "Relaxation Processes" will be held under the auspices of the Faraday Society in the Department of Chemical Engineering of the Imperial College of Science and Technology on November 27. An introduction by Prof. A. R. Ubbelohde will be followed by contributions by Prof. C. J. F. Bottcher (Leyden) on dielectric relaxation; Dr. Vera Daniel (Electrical Research Association) on dielectric relaxation in crystals containing hydrogen bonds; Mr. W. Reddish (Imperial Chemical Industries, Ltd., Plastics Division) on relaxation in high polymers in the solid state; and Dr. J. Lamb (Imperial College) on ultrasonic relaxation in liquids. Further information can be obtained from Dr. J. C. McCoubrey, Department of Chemical Engineering, Imperial College of Science and Technology, London, S.W.7.

IN *Nature* of October 18, p. 1060, the list of Waverley awards was printed; a special award was announced in the official list as being made to Mr. M. D. Lilley. This was incorrect; the award was made to Miss M. D. Lilley, of Aplin and Barrett, Ltd.

ERRATUM. In the communication "Removal of Gases in High Vacuum Systems by Metal Abrasion", by M. E. Haine, E. W. R. Francis and R. N. Bloomer in *Nature* of October 4, p. 931, par. 2, line 7, for "litres/µsec." read "litre microns per sec."; the 'litre micron' is a unit of quantity of a gas where the volume of the gas is in 'litres', the pressure of the gas is in 'microns' (10^{-3} mm. mercury).

ORIGINS AND PHILOSOPHY OF TECHNOLOGY

LARGE corporations both in the United States and Britain have recently been giving attention to the more metaphysical aspects of the power they embody or produce, and considering the direction of the steps they intend to take in the second half of the twentieth century. In the United States, General Motors employed Peter Drucker to sketch for them "The Concept of the Corporation". In Britain, from the periphery of an industrial conference, similar heart-searchings are visible. Perhaps the best description for this activity is Adolf Berle's "Matrix Work", which he defined as "tending towards a body of sophisticated thinking whose aim, properly organized, is a concept of a community making for the good life".

Big bites into the edges of this vast and important sphere of thinking have just been made by the Electricity Council. Its chairman, Sir Henry Self, is particularly well qualified to do so, for in the midst of a distinguished career at the Board of Trade, the Post Office, the Foreign Office, the War Office, the Air Ministry and the British Electricity Authority, he has found time to supplement his originally scientific training by separate academic qualifications in mathematics, divinity, classics and philosophy. Having ploughed, harrowed and sown such diverse fields, all in their way fertile, he has now been winnowing the harvest of a life-time. Moreover, as president of the Modern Churchman's Union he is particularly concerned with presenting in contemporary terms a teleology of the modern world. He sees the universe as a complex of experience in every conceivable form at any possible level. He cites the collect in the "Book of Common Prayer" that prays for the grace not only to "read, mark and learn" but also to "inwardly digest" that which is "written for our learning". His introduction to the eight lectures* which were delivered to an invited audience of members of the senior staff of the Electricity Supply Industry in the autumn of 1956 emphasizes the inward nature of this digestive process.

As an aperitif, he has assembled three well-known figures to present the fruits of their work on the history of science: Prof. H. Dingle, Prof. D. McKie and Dr. P. Dunsheath. Each takes two strands of human thought and development which has fundamental significance for an understanding of our times and which, in Sir Henry Self's view, can be used as "the basis for future development of twentieth century life". Prof. Dingle presents us with Galileo and the beginnings of modern science, Prof. McKie follows on with the Royal Society and the scientific academies, and of course Lavoisier and the beginnings of modern chemistry. Prof. Dingle returns with a lecture on the nineteenth century and the expansion of the physical sciences, and Dr. Dunsheath with two lectures on the engineer and human progress. Sir Henry Self has not only given the introductory and the concluding lecture but has also published a further booklet*, treating in a complementary way twentieth century science and its implications for modern thinking. In this he confines himself to the exact sciences, but promises us further supplements on biology, medicine and psychology.

To the philosopher these two booklets are interesting and significant in that they reveal Sir Henry as a disciple of that great scientific statesman, Viscount Haldane, to whom, as much as any man, we owe the foundation of the Department of Scientific and Industrial Research. For he sees society evolving through community, creative adventure and the pursuit of truth. He is concerned with the bipolar nature of man. As a twentieth century mystic in the tradition of Boehme, William Law and Coleridge (though he does not shelter behind their names) he says "we have got to try and break from the bad habit which has grown over seven centuries whereby we are so proud of our empirical development, of the idea of trial and error, experiment and test, that having developed that we have thrown away the origins, the sources, out of which it sprang". These origins and sources show man, not as a super-computor capable of grinding out thoughts, words and ideas with a brain and a nervous system, but a living embodiment of ideas which have enduring eternal value.

Texts are out of fashion. If one were to be put on the front of these two booklets it would be *Romans*, i, 20: "For the invisible things of him from the creation of the world are clearly seen, being understood by the things that are made".

W. H. G. ARMYTAGE

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* "The History and Philosophy of Science and Technology". Pp. vi+139. 9*s*. (Education and Training Department of the Electricity Council, London, 1958.)

* Sir Henry Self, "Some Implications of Modern Science". Pp. ii+18. 1*s*. 6*d*. (Electricity Council, London, 1958.)

IONS OF THE TRANSITION ELEMENTS

A GENERAL discussion organized by the Faraday Society on "Ions of the Transition Elements" was held in Dublin during September 9-11. The main object was to consider the electronic structures and properties of these ions, particularly when included in complexes. A further object was to bring together physicists whose work was concerned with the structures of these ions and theoretical and experimental chemists whose interests lay in the same direction. It was most fortunate that both Prof. L. Pauling (California Institute of Technology) and Prof. J. H. Van Vleck (Harvard University) could be present, for their names are intimately connected with two of the most important theories that have been applied to the electronic structures of these compounds.

Two introductory papers at the beginning of the meeting were given by Dr. J. W. Linnett (University of Oxford) and Prof. M. H. L. Pryce (University of Bristol). The former surveyed the theories and experimental methods that have been employed, while the latter considered, in very general terms, the special features of the electronic structures of these ions from the physicist's point of view.

The first session was devoted to four papers which dealt with optical absorption. The first, by Dr. W. P. Doyle and G. Lonergan (University College, Dublin), described some measurements on the transmission of radiation by films of cobaltous and nickelous oxides between 360 and 1,000 mμ thick. The first maxima for both were interpreted as exciton transitions. The results were discussed on the basis of crystal field theory. The next two papers both dealt with the absorption spectra of transition metal ions in lattices of Al_2O_3. Prof. Pryce and W. A. Runciman (Harwell) studied trivalent vanadium in corundum, while Dr. S. Sugano and Dr. Y. Tanabe (University of Tokyo) considered trivalent chromium in ruby. The former workers succeeded in resolving the fine structure of two absorption bands and then considered theoretically the energy-levels for two *d*-electrons in a trigonal field. Sugano and Tanabe reported on the Cr^{3+} line spectrum in ruby and also discussed its interpretation. Prof. H. Hartmann and H. Müller (University of Frankfort) measured the spectra of the hexa- and heptahydrates of nickel sulphate to compare with calculations that had been made on the $Ni(H_2O)_6^{2+}$ ion. The results satisfy the theoretical requirements. A splitting of the main bands, indicating a departure from octahedral symmetry, was observed. The discussion at this session was mainly concerned with the reasons why certain substances were very intensely coloured.

The next five papers dealt with the application of paramagnetic resonance spectroscopy to transition metal ions. Dr. J. Owen (University of Oxford) reviewed the use of electron- and also nuclear-resonance to measure electron transfer. He also considered superexchange between pairs of iridium ions in mixed crystals of $(NH_4)_2(Ir,Pt)Cl_6$ containing sufficient iridium to ensure the presence of enough pairs of iridium ions which were nearest neighbours, but which had no other iridium neighbours. Dr. W. Hayes (Argonne National Laboratory) had studied ions such as Cr^+ and Fe^+ contained in a sodium fluoride lattice and produced there by γ-rays, X-rays or electrons. The fluorine hyperfine structure was used to measure the amount of electron transfer to the fluorines. Prof. J. E. Wertz, J. H. E. Griffiths and J. W. Orton (University of Oxford) and P. Auzins (University of Minnesota) described experiments with single crystals of magnesium oxide which contain iron group impurities. Because of the high dilution and exact cubic symmetry the lines are very narrow and in some specimens 200 lines were observed. These spectra can be used to study lattice defects.

J. F. Gibson, Dr. D. J. E. Ingram and Dr. D. Schonland (University of Southampton) presented results for electron resonance measurements of ferrihæmoglobin derivatives. A molecular-orbital treatment for these square-bond derivatives was given and the conclusions compared with the results for this and similar copper and cobalt complexes. Dr. J. S. Griffith (University of Cambridge) gave a theoretical treatment of the electronic structures of these complexes, his approach being a crystal field one. He examined his conclusions in relation to the electron resonance and magnetic susceptibility measurements.

The next two papers dealt with magnetic properties. Van Vleck discussed the magnetic anisotropy of crystals and the occurrence of inverted crystalline energy-levels. He concluded that, while the cubic part of the field is quite stable, the non-cubic part may be very dependent on the nature of the cation. Dr. B. N. Figgis, Dr. J. Lewis, Prof. R. S. Nyholm and R. D. Peacock (University College, London) measured the magnetic susceptibilities of some complexes of osmium, ruthenium, rhenium and iridium over a temperature range. The configurations de_t^3, de_t^4 and de_t^5 were involved. The results were discussed in terms of Kotani's theory.

Dr. C. K. Jorgensen (Technical University of Denmark, Copenhagen) discussed the decrease in repulsion between electrons in the *d*-shell of a complex ion compared with that in a free ion. The effect is due partly to an expansion of the *d*-orbitals because of increased screening and partly to their participation in covalent bonding. Prof. D. P. Craig and E. A. Magnusson (University College, London) also discussed this effect from a theoretical point of view and concluded that the effect could be largely explained without electron transfer into the 3*d* orbitals.

Dr. J. Chatt, L. A. Duncanson, B. L. Shaw (Imperial Chemical Industries, Welwyn) and L. M. Venanzi (University of Oxford) described measurements using infra-red spectra of the N—H vibration frequencies in various amine complexes. They discussed their results in terms of the extent and type of the electron drifts taking place. Dr. R. J. P. Williams (University of Oxford) showed that the stabilities of complexes cannot always be correlated with the ligand field-splitting factor. He concluded that stabilities should be related only to the ground-state properties and not to the excitation measured by the splitting factor.

Dr. L. E. Orgel (University of Cambridge) discussed the structure of a number of transition metal oxides, considering in particular distortions from a regular arrangement. He also examined the relation of this to the phenomenon of ferroelectricity. N. S. Hush (University of Bristol) presented graphs showing the variation in internuclear separation for the halides, oxides, etc., of the transition metals of the first long period. He also made calculations relating to these distances and contractions in them.

Dr. L. A. K. Staveley and T. Randall (University of Oxford) described measurements they had made of the heats of formation of a large number of complexes involving ethylenediamine tetraacetic acid. Combining their data with measurements of stability constants, they obtained entropy changes. The values were compared with one another and it was found that they fell into several sets. This was discussed. Dr. A. A. Vlcek (Academy of Sciences, Prague) described some work on polarographic half-wave potentials of a series of complexes and found that the potential could be correlated with the position of the ligands in the spectrochemical series. This and other results were then discussed in terms of the mechanism of the electrode process.

Throughout the meeting there was active discussion between the physicists and those chemists whose interests were definitely on the theoretical side or tended that way. But at times it did seem that there is still a great need for a better presentation of the theoretical ideas and nomenclature to the chemists whose activities are more largely experimental.

J. W. Linnett

THE CENTENARY OF 'DARWINISM'

THE Linnean Society has issued a special number of its journals in celebration of the centenary of the first publication of the theory of evolution by natural selection in the papers by Darwin and Wallace given to the Society in 1858*. The number contains thirteen papers, mostly by Fellows of the Society. Three of these deal with Darwin and the development of his theory during the intervening century, and the rest with modern work on evolution, five botanical and five zoological.

The first of the three contributions on Darwin's life and theory is Sir Julian Huxley's lecture on "The Emergence of Darwinism", which was given at the inaugural meeting of the fifteenth International Congress of Zoology last July. The lecture is an evaluation of Darwin's work in the light of our more recent knowledge. In particular, Huxley stresses the part of good fortune in Darwin's career, especially in providing him with the background required for his work. Even his delay in publishing his theory was fortunate, for the world was not ready for it earlier. So also was the intervention of Wallace, without which he might never have published, or, at least, not in the readable form in which it appeared. The lecture gave a most appropriate introduction to the Congress—as it also does to this publication—in emphasizing Darwin's outstanding quality as a biologist, not always sufficiently appreciated in modern times.

In his essay on Darwin's views on embryology and evolution, Sir Gavin de Beer discusses chiefly how far Darwin believed in Haeckel's theory of recapitulation. In the first edition of "The Origin" he was unwilling to accept the essential thesis of the theory, that life-histories evolve by addition of new stages at their ends, but he seems to have been persuaded by Fritz Müller and Haeckel to a still somewhat cautious acceptance, being in this matter led astray, perhaps because he realized that his knowledge of embryology was not wide. de Beer also believes that in at least one quotation Darwin anticipates the theory of pædomorphosis. This seems, to me, at least doubtful; the quotation can be read as doing no more than express doubts about the more extreme forms of the recapitulation theory.

In his article on "Darwin, Wallace and 'Preadaptation'", Dr. Harrison Matthews discusses the intellectual climate at the time of the publication of "The Origin", emphasizing, as did Sir Julian Huxley, the value to Darwin of the progress of thought in the preceding years and of the fact that in 1859—but not ten years earlier—younger men such as T. H. Huxley were available to support the new theory.

As a zoologist and not a botanist, I cannot discuss the botanical papers in detail. In his presidential address on fossil plants, Dr. Hamshaw Thomas gives an account of a great deal of recent work and shows that much evolution in plants has been by development of new structures rather than by modification of structures already present—the parts of the flower are not modified leaves. Dr. W. B. Turrill in his Hooker Lecture discusses the evolution of floras, with special reference to the Balkan peninsula; Dr. E. J. H. Corner has a paper on change of function in the organs of plants and the part it has played in evolution; Prof. I. Manton writes on chromosome numbers and the phylogeny of ferns; and Dr. Darnley Gibbs on the production of chemical substances in plants.

The longest of the zoological papers is Dr. S. M. Manton's summary of her work on locomotion in the arthropods. This will be useful to many who are not specialists in the subject and find her original papers longer than they can absorb. Prof. O. M. B. Bulman has an interesting paper on the evolution of colonial form in the graptolites, and Dr. E. B. Ford writes on the work of the Oxford zoologists on evolution in natural populations. In a paper on the problems of reptile classification, Mr. F. R. Parrington discusses much recent work and comes to the conclusion that there is no reason for thinking the reptiles diphyletic; all their groups are descended from primitive captorhinomorphs which were already reptiles. Finally, Dr. G. Pontecorvo writes on the versatility in evolution shown by the hereditary systems of organisms, both in typical holozygotic reproduction and in more primitive types.

Anyone interested in one or more of the many subjects dealt with in these papers will find something of value in this publication. It seems an excellent way to celebrate the centenary.

G. S. CARTER

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* Darwin-Wallace Centenary. *J. Linn. Soc., Lond.* Botany, 56, No. 365; Zoology, 44, No. 205: pp. 1-152 (1958).

WATER FLUORIDATION AND DENTAL CARIES

THE Swedish Royal Medical Board has submitted a report to H.M. The King of Sweden concerning the use of fluorides in the prophylaxis of dental caries.

Swedish experts have been considering for a long time the prevention of dental caries by means of fluorides. In 1952 the Swedish Royal Medical Board appointed experts to study the question, and in 1955 the Board reported to the Swedish Government that the addition of fluorides to drinking water would be a valuable means of preventing the widespread dental caries; but the four members of the Scientific Council of the Board were doubtful about possible toxic effects of fluorides, even at the low concentrations present in drinking water, and the Board then preferred to await the outcome of further research. Meanwhile, it recommended the prohibition of fluoridation of public water supplies.

In 1957, however, a committee, consisting of Prof. Sven Sellman, Prof. Yngve Ericsson and Prof. Allan Strålfors, considered the prophylaxis of dental caries with emphasis on the use of fluorides for this purpose. This committee has presented, since 1958, more than one report. Members of the Scientific Council of the Royal Medical Board have also expressed their views.

There is general agreement that there are three principal methods of prophylaxis of dental caries, namely, administration of fluorides by vehicles other than water supplies, such as tablets, milk, common salt, flour and bone-meal, which the committee cannot recommend until further investigations have been made ; topical application of fluoride to the teeth, which should, the committee thinks, be investigated clinically under the control of the Royal Medical Board ; and fluoridation of the public water supplies.

With regard to this last method, the Board now reports that fluoridation of public water supplies does not involve any demonstrable hazards to health. It should, however, be carried out under strict control and care should be taken that, where it is instituted, the people are not exposed to fluorides derived from any other sources, such as foods or industrial gases. The Board reports that it has been found that a concentration of about 1 mgm. of fluoride per litre of water will reduce the incidence of dental caries by about 50 per cent in children and young persons who have consumed this water all their lives. In other children the caries will be reduced roughly in proportion to the period of consumption of the water. Fluoride also seems to protect the teeth of middle-aged people. A slight mottling of the enamel of the teeth appears in some children who have drunk water containing 1 mgm. of fluoride per litre during the period of tooth formation.

The technique of fluoridation of water is simple and has been thoroughly tested, but it is not applicable to those large groups of people in Sweden who have no access to a public water-supply. In Stockholm and Gothenburg the costs of fluoridation have been estimated at 0·3–0·4 Swedish crowns per person per year, or, when it is restricted to school children, 3–4 crowns per child per year. At present, expenditure on the public dental service for school children is about 75 crowns per child per year, and dental caries is so widespread that all available means of combating it must be used. In Sweden the city of Norrköping fluoridized one of its two public water supplies five years ago, and in Uppsala, Eskiltuna and Hälsingborg the public water supplies naturally contain more fluoride than is used for artificial fluoridation. The Board points out that in other countries in which fluoridation is used no evidence has been found that it harms health, and that both the American Medical Association and the World Health Organization have unreservedly recommended fluoridation as an effective and safe means of preventing dental caries.

The World Health Organization Expert Committee on Water Fluoridation, in its first report*, also concludes that drinking water containing about 1 p.p.m. fluoride has a marked preventive action on caries and does not impair health, and that controlled fluoridation of water is a practicable and effective public health measure.

G. Lapage

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* World Health Organization. Technical Report Series, No. 146: Expert Committee on Water Fluoridation—First Report. Pp. 25. (Geneva: World Health Organization; London: H.M. Stationery Office, 1958.) 1 Swiss franc; 1s. 9d.; 0.30 dollars.

HOST – PARASITE RELATIONSHIPS

The subject of host – parasite relationships covers such a wide field that the four papers on this subject, presented on September 3 in Section *M* (Agriculture) of the British Association meeting in Glasgow, not unexpectedly had comparatively little in common. Nevertheless, this diversity of interest helped to emphasize the fact that few living creatures escape the attention of some parasite or other, and that many specialized adaptations are necessary for parasitic life. Equally elaborate defence mechanisms have been evolved by potential hosts. The struggle for survival is governed very largely by the efficiency of these predatory or defending mechanisms.

Dr. J. A. Campbell (Moredun Institute, Edinburgh) explained that, among the insects, the true flies or Diptera apparently adopted the parasitic mode of life comparatively late in their evolutionary history. For this reason the flies show various degrees of adaptation to parasitism which can provide some information on the probable course of development of the habit. Morphological studies provide good evidence that the blood-sucking habit was evolved independently at different times in the various families. The behaviour patterns among the higher flies (Cyclorhapha) suggests that the course of evolution developed from generalized feeding on a wide variety of hosts to a more specialized association within a narrow range of hosts and even to complete dependence on a single species.

The stable fly (*Stomoxys calcitrans*), for example, feeds on a wide range of hosts, including man and most farm animals. Its larvæ can live in a variety of decomposing material, including dung heaps. The horn fly (*Lyperosia irritans*) is more specialized. The adults feed only on cattle, while the larvæ are confined to cattle dung. In the case of the sheep tick (*Melophagus ovinus*) dependence on a single host is complete. The fly has no wings, its larvæ are nourished *in utero*, and pupation occurs on the host.

There are many examples of the development of allergic sensitivity to insect bites. In some cases this can be recognized as a distinct clinical syndrome, such as Queensland itch in horses due to attacks of *Culicoides*. Insect saliva has been shown to be antigenic and the injection of this saliva can lead to the development of neutralizing antibodies in the host. So far as the hosts of blood-sucking flies are concerned, there is little doubt that for a variety of reasons some members of a species are more resistant to attack than others. There is no evidence, however, that specific immune reactions have any effect on the rate of infestation.

Dr. J. R. Norris (University of Glasgow) discussed the result of some recent work, largely done by two Canadian workers, Hannay and Angus, on the spore-bearing bacteria, *Bacillus thuringiensis*, which infect meal moth larvæ, and *Bacillus sotto*, which cause a septicæmic disease of silkworms.

Both organisms are capable of developing large protein crystals within their cytoplasm. If silkworm larvæ are fed with cultures of *B. sotto* containing both spores and protein crystals, they first become paralysed and then develop a septicæmia as the bacteria penetrate into the body cavity. If the same culture is injected into the body cavity, the organisms multiply and produce a septicæmia but no paralysis occurs. The spores themselves are harmless if fed without the protein crystals, although they cause a septicæmia without paralysis if injected into the body cavity. The protein crystals can be extracted from the bacteria and cause paralysis and death if fed to the larvæ, but not if injected into the body cavity.

It seems, therefore, that the protein crystals are necessary for the penetration of the bacteria through the gut wall, and that the protein itself requires to be activated by the gut contents before it becomes toxic.

Dr. Norris also discussed the possible relationships between *B. cereus*, *B. thuringiensis*, *B. sotto* and *B. anthracis*. It is quite clear that there are a number of interesting problems to be solved in connexion with the pathogenicity of this group of organisms.

Dr. W. Mulligan (University of Glasgow) described the results of recent work on parasitic bronchitis of cattle which has been done at the University Veterinary School. This disease, caused by the lung worm *Dictyocaulus viviparus*, is responsible for serious debility among calves both in Britain and abroad. Severe attacks can be fatal. The disease may sometimes be cured by drugs which destroy the worm in the bronchi, but the treatment is usually too late to prevent severe damage to the lungs. Nevertheless, cattle gradually develop a satisfactory immunity after repeated exposure to natural infections. Dr. Mulligan and his colleagues have shown that calves can be protected against experimental infections of lung worms by injections of immune sera from animals which have recovered from the disease. This [illegible]ation of the passive transfer of immunity [illegible]n beyond all reasonable doubt that calves [illegible]duce protective antibodies against *Dictyocaulus* [illegible]*arus*. The knowledge that circulating antibody [illegible] protect calves is of great value and a step forward [illegible] our understanding of the disease. Unfortunately, for practical reasons, this method of immunization cannot be used on the average farm. There is little doubt that the best method of prevention would be to find some means of artificially inducing an active immunity in otherwise susceptible animals. Attempts to immunize calves with various preparations of dead lung worms were apparently not very successful.

As natural infections gradually produce an active immunity, a trial was made with living vaccines consisting of larvæ which had been exposed to X-rays. It was hoped that larvæ treated in this way would survive for long enough in the calf to stimulate an active immunity and yet be incapable of causing progressive disease. Living vaccines of this type show great promise. It is thought that two doses of vaccine may give the best results, and an intensive trial is being made of this method. If these trials are successful, this vaccine should be of the greatest value to cattle owners in all parts of the world.

Dr. J. J. Bullen (Rowett Research Institute) discussed some of the factors which can influence the multiplication of pathogenic bacteria within a host. Examples were chosen from two experimental infections, enterotoxæmia of sheep and *Clostridium welchii* type *A* infections in embryonated hen's eggs.

The organism responsible for enterotoxæmia of sheep, *Cl. welchii* type *D*, is a normal inhabitant of the intestine. In certain circumstances, these bacteria multiply extremely rapidly and produce large quantities of toxin which is absorbed and kills the sheep. The disease cannot be reproduced in normal sheep fed on ordinary diets such as hay even if large numbers of *Cl. welchii* type *D* are introduced directly into the intestine. Viable counts of the bacteria in the living animal show that the bacteria cannot multiply fast enough to maintain their numbers and are soon removed by the normal flow of the intestinal contents. If the diet is suddenly changed, to wheat, for example, and the sheep overeats, the rumen becomes filled with undigested food. In the intestine this provides an ideal substrate for *Cl. welchii* type *D*. Very large numbers of the bacteria accumulate in the intestine. Large quantities of toxin are produced and the animal dies from acute enterotoxæmia. Thus, the diet of the sheep appears to play an important part in the development of this disease.

The experiments with eggs show that suitable antisera and, in certain circumstances, normal sera, can protect embryonated hen's eggs against normally fatal infections with *Cl. welchii* type *A*. The sera and bacteria are injected into the allantoic cavity. In unprotected eggs the organisms grow in the allantoic fluid and then invade the tissues of the embryo. In protected eggs the growth of the bacteria stops after an hour or two. There is no cellular response on the part of the host and no phagocytosis. Experiments of this kind appear to be useful for investigating the effect of sera on the growth of pathogenic organisms in the living host.

J. J. BULLEN

CHARGE-TRANSFER PROCESSES

A SYMPOSIUM on "Charge Transfer Processes", sponsored by the division of the Chemical Institute of Canada devoted to physical chemistry, was held during September 4–5 at the University of Toronto. The meeting, which had been organized under the chairmanship of Dr. B. E. Conway (University of Ottawa), was concerned with various aspects of the physical chemistry of reactions in which transfer of a formal charge occurs. Both homogeneous redox reactions and heterogeneous electrochemical reduction and oxidation processes were considered. About seventy-five physical chemists from the United States, Great Britain and Canada attended the academic sessions. Twenty-seven papers were presented, and each author was allowed ten minutes to describe the essential results of his work, all papers having been preprinted and circulated to participants several weeks before the meeting. About half the total time of the meeting was devoted to erudite and lively discussion of the papers presented. The meeting was honoured by the presence of a number of invited speakers from overseas, including Dr. D. J. G. Ives (Birkbeck College, London), Dr. J. E. B. Randles (University of Birmingham) and Dr. R. Parsons (University of Bristol). Prof. A. Frumkin (Academy of Sciences, Moscow), who had been invited, sent a paper for presentation but was regrettably unable to be present. On the evening of September 4, participants at the symposium repaired to St. Michael's College for a reception and later took dinner at the Howard Ferguson Hall.

Prof. F. E. W. Wetmore (University of Toronto) opened the meeting by welcoming the participants. The first session, on "Homogeneous Processes", with Dr. B. E. Conway in the chair, was opened with a paper by Dr. H. Taube (University of Chicago) on bridging and simple ligand effects in electron transfer reactions; Dr. Taube discussed changes which took place in the inner and outer co-ordination spheres of ions when these ions underwent oxidation or reduction. This was followed by theoretical contributions by Dr. K. J. Laidler (University of Ottawa) on electron-transfer reactions in aqueous solutions, and by Dr. R. A. Marcus on electrochemical and chemical-electron transfers. In these papers the factors involved in the electron transfer process and the solvent redistribution which occurs upon the transfer of a charge were examined. In the paper by Dr. K. J. Laidler, repulsion effects which arise upon the approach of ferrous and ferric ions in aqueous solution were calculated quantitatively, allowing for dielectric saturation. Electron transfer occurs by tunnelling. An optimum free-energy barrier exists for which the rate constant has a maximum value. A free energy of activation in good agreement with that determined by experiment was deduced. The applicability of the Franck–Condon principle to these processes was discussed at length. Dr. J. Halpern (University of British Columbia) examined the applicability of the principle of equi-valence change to inorganic oxidation-reduction reactions in terms of the kinetic parameters of a number of selected redox reactions. Drs. I. H. Henderson, R. L. Haines, E. G. Lovering and E. J. Casey (Defence Research Board, Canada) presented data on the equivalent redox potential of aqueous solutions under γ-irradiation. The session on homogeneous processes was concluded with two papers on the mechanism of anomalous proton mobility in hydrogen-bonded systems. Dr. M. Kilpatrick (Illinois Institute of Technology) discussed the limiting conductance of lyonium and lyate ions with particular reference to some anomalous non-aqueous systems, and Dr. B. E. Conway, speaking on the role of proton tunnelling in certain charge transfer processes, described measurements on the conductance of heavy-ice and discussed the theoretical significance of the ratio of mobilities of hydrogen ions and deuterium ions in water, heavy-water and the corresponding ices, in terms of a proton-tunnelling mechanism. A theoretical examination of the possibility that proton tunnelling also occurred in certain electrode processes involving hydrogen was given and criteria for recognition of such an effect were presented.

The second session, with Dr. J. E. B. Randles in the chair, was devoted to the mechanism of cathodic electrochemical reactions. The mechanism of electrolytic silver deposition was discussed in a paper by Drs. W. Mehl and J. O'M. Bockris, who had used a galvanostatic technique. The results, together with certain theoretical considerations, led to the conclusion that surface migration of adsorbed silver atoms or 'partial ions' was the rate-determining process at low cathodic potentials, while ionic transfer from the double-layer to the surface was the slow step at higher potentials. Dr. C. V. King (New York University) discussed the kind of information that can be obtained from studies of exchange between metals and their ions in solution, and emphasized that care must be taken in the interpretation of exchange data owing to complications arising from bulk diffusion and other factors. The mechanism of growth of electrolytic metal whiskers was discussed in a paper by Dr. D. A. Vermilyea (General Electric Co.) in terms of the theory of crystal growth and the role of adsorbed inhibitors. Some abnormal hydrogen electrode reactions at gold were described by Dr. D. J. G. Ives (University of London) and a desorption reaction involving H_2^+ molecule-ions was discussed in an attempt to rationalize observations concerning reduction of tungstic oxide 'at a distance' from the electrode. Mr. A. Antoniu and Dr. F. E. W. Wetmore (University of Toronto) gave some further data on the hydrogen evolution reaction at silver. Inflected Tafel lines exhibiting slopes of 0·059 and 0·112 were observed as found in previous work, and the heats of activation ($\Delta H^{\ddagger}$) were determined for the two parts of the lines. A difference of about five kilocalories in $\Delta H^{\ddagger}$ for the two processes involved was deduced; a change of mechanism of the reaction with increasing cathodic potential was indicated. Experiments on transport of hydrogen through palladium-clad electrodes were described in a paper by Drs. S. Schuldiner and J. P. Hoare (U.S. Naval Research Laboratory). Diffusion was detected by measurement of the polarization built up on the non-polarized side of a diaphragm electrode. The effect of cladding other metals (iron, nickel, gold) with palladium was examined.

The third session, on September 5, with Dr. B. E. Conway in the chair, was concerned with electrochemical reductions other than those involving hydrogen or metal deposition. Dr. J. E. B. Randles discussed the determination of kinetic parameters of redox reactions from current-potential curves and
a.c. impedance methods and referred to exp
results on the V^{3+}/V^{2+} reaction at mercury el
The two methods give similar results if appr
calculation of concentration polarization effec
made. The mechanism of reduction of chloraq
chromium-III ions in acid media, studied at the dro
ping mercury electrode, was discussed in a paper by Drs. H. Elving and B. Zemel (University of Michigan). At low acid concentrations a dual electron-transfer mechanism involving the electrode and chromium-II ions is suggested, while for $[CrCl_2.4H_2O]^+$ in 12 *M* hydrochloric acid a simple direct electron-transfer process is indicated. Dr. M. J. Allen (Ciba) described some problems in the study of organic electrochemical reductions.

A group of papers then followed on anodic processes. Dr. E. S. Snavely and N. Hackerman (University of Texas) described some analytical and coulombic studies on the anodic passivation of iron, and Dr. M. Cohen (National Research Council of Canada) discussed the formation and properties of passive films formed on iron under various conditions, for example, the presence or absence of oxygen or the presence of inhibiting ions. Some theoretical considerations on the mechanism of growth of anodic oxide films were presented by Dr. L. Young (British Columbia Research Council). Dr. B. E. Conway and P. L. Bourgault (University of Ottawa) described some studies on the kinetics of self-discharge of nickel – nickel oxide electrodes. The decay of electromotive force and rates of evolution of oxygen had been measured on open circuit over a wide range of concentrations of potassium hydroxide and the kinetics interpreted in terms of a scheme of consecutive reactions for rate-determining oxygen evolution at anodic sites on the oxide.

The final session of the meeting, with Dr. S. Schuldiner in the chair, was concerned with the double-layer and adsorption at electrodes. The correlation between double-layer capacity and kinetics of electrode processes was examined in a paper by Drs. M. Breiter and P. Delahay (Louisiana State University), and Drs. R. S. Hansen and D. A. Hickson (Iowa State College) presented some interesting results on the apparent dependence on frequency of the capacity of the double-layer; relaxation times for water in the double-layer as high as 10^{-2} sec. were deduced. This occasioned some discussion, since it was pointed out that even in the ice lattice, where the water is strongly bound, the relaxation time is much smaller (about 10^{-6} sec.). Dr. R. Parsons (University of Bristol) read the paper by Prof. A. Frumkin (Academy of Sciences, Moscow) on the influence of surface-active anions on the electro-reduction of persulphate anions at negative potentials; the acceleration of the reduction of $S_2O_8^{2-}$ which was observed in the presence of surface-active anions was explained in terms of their effect on the potential (ψ_1) at the outer Helmholtz plane in the double-layer. Specific effects of cations on the kinetics required that a local fluctuating ψ_1-potential due to interaction of the adsorbed anions with cations in the double-layer be considered. A general thermodynamic analysis for the determination of heats of adsorption in ionic systems by electrocapillary studies was given in a paper by Dr. R. Parsons and results obtained for the isotensile heats of adsorption of potassium iodide at mercury were discussed. The meeting concluded with two papers describing the adsorption of hydrochloric acid and aromatic aminium salts at mercury by the electrocapillary method (Drs. E. Blomgren and J. O'M. Bockris, University of Pennsylvania) and the adsorption of methylene blue at mercury by collecting a large number of mercury drops which had fallen through the solution and analysing for the dye carried down in the double-layers of the drops (Drs. J. M. Los and C. K. Tompkins, University of New Brunswick). Some results from studies on the direct determination of adsorption of organic ions at solid metals were presented by Dr. B. E. Conway and Mr. R. G. Barradas in discussion.

Most of the papers presented at the meeting will be published early in 1959 in the *Canadian Journal of Chemistry*.

B. E. CONWAY

EAST MALLING RESEARCH STATION

ANNUAL REPORT

THE annual report of East Malling Research Station for 1957* contains some important research findings. A new semi-dwarfing apple rootstock, *M* 26, is described by W. S. Rogers; it is intermediate in vigour between *M* IX and *M* VII, and so fills a unique place. The elimination of virus from strawberry clones by heat therapy increased the fruit yield of several varieties, though the crop ripened later, and was more prone to *Botrytis* rot than untreated plants. In Early Cambridge and Rearguard, however, there was excessive vigour and a decrease in yield (W. S. Rogers and Muriel G. Fromow). Rooting and growth of root cuttings from the apple rootstock Crab *C* declined with increasing age of establishment of the parent plant, according to results obtained by R. J. Garner and E. S. J. Hatcher. Raspberry breeding work, by R. L. Knight and Elizabeth Keep, is now mainly concerned with the introduction of resistance to the virus vector *Amphorophora rubi* and to cane spot and *Botrytis*, while interspecific hybrids are being sought between black-currant and gooseberry. The apple breeding work of H. M. Tydeman shows progress towards a late-flowering variety which will be resistant to scab and mildew.

Two papers in the physiological section show that, in the British climate, temperature is perhaps the most important factor in fruit growth. C. R. Hancock and H. W. B. Barlow show that growth-rate of Crab *C* shoots was related to temperature and day-length, though the final internode length was less dependent on temperature and had little relation with the daily period of light. The same authors found that the effects on leaf growth of a summer gale in 1956 were mainly due to the fall in temperature. D. H. Maggs has compared growth of the rootstocks *M* II and *M* XVI with differences in time of leaf-break eliminated; the former produced more stem and the latter more root for plants of the same weight. *M* II had a smaller increase in weight produced per gram of leaf than *M* XVI.

Symptoms of magnesium deficiency in apple rootstocks can best be eliminated by foliar spraying with Epsom salts. Elsie M. Ford shows that this method is better than soil application and that it is not enough merely to remove the symptoms, for three sprays are necessary to bring increased vigour.

The virus disease known as little cherry causes serious damage in North America, and now A. F. Posnette and R. Cropley have reported it in Great Britain. G. W. F. Sewell and J. F. Wilson report another new trouble in that some common hop garden weeds have been found susceptible to the 'progressive' strain of the hop wilt fungus *Verticillium albo-atrum*. There were earlier indications that the hop virus 'nettlehead' was in some way linked with nickel content of the plant. J. T. Legg and P. J. Ormerod find that the symptoms of nickel toxicity and of nettlehead are distinct, though presence of the virus is associated with higher contents of some heavy metals than are found in healthy plants. R. S. Pitcher shows that the life cycle of the currant leaf midge *Dasyneura tetensi* varies considerably from year to year. This brings difficulties of timing control measures and demonstrates the necessity for more persistent toxicants. A study of *Blepharidopterus angulatus* by R. C. Muir is mainly an evaluation of the capture–recapture method of estimating orchard insect populations. Phytotoxicity studies by A. H. M. Kirby and Margery Bennett show that a number of acaricides are safe to use on the varieties of black currant and plum used for test. On the other hand, phenyl mercury chloride caused direct damage to pears in each season, irrespective of weather conditions.

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* Kent Incorporated Society for Promoting Experiments in Horticulture. Annual Report of East Malling Research Station, 1st October, 1956, to 30th September, 1957. (Forty-fifth year.) Pp. xxv+173. (East Malling, Maidstone: East Malling Research Station, 1958.) 17*s.* 6*d.*; 2.50 dollars.

The report contains the text of the Amos Memorial Lecture by F. C. Bawden on viruses and virus diseases —a most useful general review. It has also papers on methods of recording, sampling and experiment. There is a detailed paper on soil management effects on a number of chemical and physical properties of the soil (J. E. Goode and G. C. White) the practical implications of which are discussed in one of the four bulletins for fruitgrowers. A review, however, should lay a train of anticipation leading to the detail of the report itself. It is a current guide to the enlarging horizon of the application of science to the culture of fruit.

NEW HYDROXYAMINO-ACIDS IN PLANTS AND THEIR IDENTIFICATION

Hydroxyvaline in *Kalanchoe daigremontiana*

THE first application of two-directional paper chromatography to the investigation of soluble nitrogen compounds in plants was reported in *Nature* in 1947[1], and paved the way for the recognition of many new free amino-compounds in plants. By the application of the new techniques, the list of naturally occurring amino-acids became rapidly extended, for hitherto the emphasis had been upon the demonstration, in the free state, of the protein amino-acids and of the amides, asparagine and glutamine. The course of these discoveries has been summarized in a series of reviews[2] which show the unexpected range of structure which natural amino- and imino-acids display.

The hydroxyamino-acids represent a special category of compounds which have been largely revealed by chromatographic methods, and, as will be seen, the final identification of these substances presents special difficulties and problems.

Prior to the development of paper chromatography, serine and threonine were the only non-phenolic hydroxyamino-acids known with certainty to occur widely distributed and free in Nature. Hydroxyproline and a hydroxylysine of uncertain structure were known in collagen but not known free in plants. Reports of the presence of β-hydroxyvaline[3] and β-hydroxyglutamic acid[4] remained unconfirmed and eventually proved to be erroneous[5]. Since the application of chromatographic methods, the following hydroxyamino-acids have been found in plants: allohydroxy-L-proline[6]; hydroxy, methylproline[7]; 5-hydroxypipecolic acid[8]; 4 (or 3)-hydroxypipecolic acid[9]; homoserine[10]; γ-hydroxyglutamic acid[11]; dihydroxyglutamic acid[12]; γ-hydroxy, γ-methylglutamic acid[8c]; α-amino, γ-hydroxypimelic acid[13]; and α,ε-diamino, β-hydroxypimelic acid (tabtoxinine)[14]. However, only in the case of allohydroxy-L-proline[6] has the evidence for these new amino-acids been brought to completion by the synthesis of the compound in question followed by the resolution of the appropriate stereoisomer and the critical comparison, by appropriate physical and chemical methods, of the natural and synthetic products. In one difficult case, involving three centres of asymmetry, the amino-acid in question (tabtoxinine) on synthesis[15] was found to have a structure different from that first assigned (Braun, A., private communication). The final identification of new compounds with one or more centres of asymmetry, therefore, should include their stereoisomeric configuration; and this being so, more readily applicable methods of optical resolution are needed so that the final identification of these new substances need not lag so far behind their recognition as at present.

Information in both parts of this contribution will extend the general recognition of compounds of this type to include γ-hydroxyvaline and O-acetylhomoserine.

Hydroxyvaline was first recognized as an unidentified, ninhydrin-reactive spot on paper chromatograms of an alcohol-soluble extract of crowngall tumours from *Kalanchoe daigremontiana*[16] and was described as 'Unknown No. 75' in a review[2b]. Subsequent studies showed it to be present in leaves and stems also, but, as yet, only in this single species of *Kalanchoe*. The substance is not found in *K. beharensis, longiflora, sexangularis, marmorata, tomentosa, verticillata, gastonis-bonieri* or *pinnata*, nor has it been detected in the many other species of plants which have been examined in this laboratory chromatographically.

On hydrolysis of crude extracts, unknown 75 partially disappears with the concurrent appearance of a second unknown, No. 78, and glutamic acid. The position of Nos. 75 and 78 on a chromatogram are shown in Fig. 1. This preliminary result was first interpreted to mean that two unknown amino-acids occupied identical positions on the chromatograms, and that only unknown No. 75 broke down to give No. 78, while the acid-stable material in the same position as No. 75 was assigned the number 76.

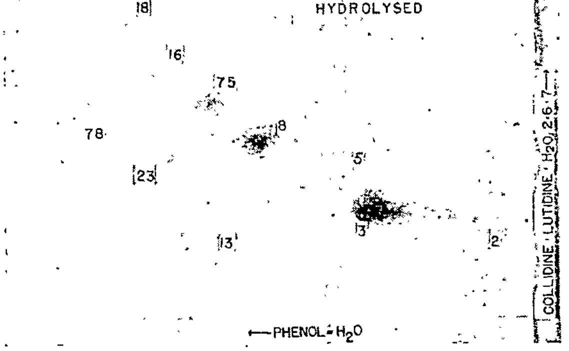

Fig. 1. Two-directional chromatogram, treated with ninhydrin, of the soluble compounds of *Kalanchoe daigremontiana* (copied from an original photograph in colour).
Numbered key to amino-acids: 2, aspartic acid; 3, glutamic acid; 5, glycine; 8, alanine; 13, arginine: 16, valine; 18, leucines; 23, γ-aminobutyric acid; 75 and 78, γ-hydroxyvaline and its lactone, respectively. (Nos. 75 and 78 react violet with ninhydrin)

Because of a general interest in glutamyl compounds[17], an attempt was made to isolate No. 75 and to determine its relationship to Nos. 76, 78 and to glutamic acid. An alcoholic extract from 60 gm. of lyophilized crowngall tumours of *Kalanchoe daigremontiana* was fractionated on 'Dowex'-50 × 4 after the methods of Partridge and Brimley[18]. Unknown No. 75 came off the column with the neutral amino-acids, whereas Nos. 76 and 78 came off the column with the bases, in fact, even slightly after arginine. In the ammoniacal eluate, No. 78 rapidly disappeared with the appearance of more of No. 76. Since several fractions then contained pure 76, it was easily shown that No. 76 was largely converted to No. 78 on acid hydrolysis and that ammonia hydrolysis reconverted No. 78 completely to No. 76. This tentatively identified No. 78 as a lactone with basic properties, produced by acid hydrolysis from the neutral hydroxyamino-acid, No. 76. Furthermore, unknowns Nos. 75 and 76 were not distinct but identical, and any confusion between them arose from the position of the equilibrium attained during acid hydrolysis, an equilibrium largely in favour of the lactone (No. 78) but with enough of the free amino-acid remaining to give the erroneous impression on chromatograms that a mixture of a stable and an unstable compound was involved. The appearance of glutamic acid on hydrolysis of the crude extracts is thus shown to be independent of the destruction of No. 75, and must arise from some other, still unidentified, source.

Having isolated No. 75 in the general manner indicated, an elemental analysis corresponded to the formula $C_{4\cdot97}H_{11\cdot33}NO_{3\cdot03}$ or $C_5H_{11}NO_3$; this could then be a hydroxyvaline. The Crumpler and Dent[19] test indicated an α-position for the amino-group and the ease of formation of lactone requires a γ- or δ-position for the hydroxy-group. Of the various compounds which would fit these requirements, α-amino, γ-hydroxy-*n*-valeric acid and α-amino-δ-hydroxy-*n*-valeric acid were obtained and shown to be readily separable from No. 75 on paper chromatograms, as was β-hydroxyvaline. The other two possibilities, namely, α-methylhomoserine and N-methylhomoserine, have not been obtained; however, neither α-methylamino-acids nor N-methyl amino-acids react quickly to give the typical violet colour with ninhydrin as does No. 75, and on this basis these two possibilities may also be tentatively eliminated.

At this point, all the indications were that No. 75 was γ-hydroxyvaline of unspecified stereochemical configuration, but this compound had never been synthesized and was unavailable for comparison. A new synthesis was required. One of us (E. S.) then prepared γ-hydroxyvaline by amination of α-chloro, β-methyl, γ-butyrolactone as follows.

The α-chloro, β-methyl, γ-butyrolactone was prepared by a modification of the method of Fleck and Shinz[20], hydrogenating α-keto, β-methyl, γ-butyrolactone in absolute ethanol with palladium-on-charcoal catalyst. The resulting α-hydroxy compound was converted to the α-chloro compound by refluxing with thionyl chloride in pyridine. This in turn was aminated in concentrated aqueous ammonia containing ammonium carbonate at 60° C. in a pressure flask for four days. This reaction mixture was passed over 'Dowex'-50 × 4, on which the amino-acid was retained and from which it was eluted with *N* ammonia. The product crystallized from the concentrated, syrupy eluate on addition of absolute ethanol, and after three recrystallizations showed a melting point of 209–11° C. (corrected). Elemental analysis gave C, 45·50; H, 8·25; N, 9·64; calculated: C, 45·11; H, 8·32; N, 10·5. Only the nitrogen value differed significantly from the calculated value.

Since the synthetic product and its lactone corresponded exactly with Nos. 75 and 78, respectively, on paper chromatograms in phenol – water, in butanol – acetic acid – water, and in collidine – lutidine – water, and because of the chemical evidence available, these two unknowns are now recognized as γ-hydroxyvaline and its lactone. Attempts to confirm this by reduction of natural γ-hydroxyvaline to valine with red phosphorus and hydriodic acid failed, only the lactone being formed in the treatment. Comparison of the infra-red absorption curves and the melting points of the synthetic and natural preparations showed differences, as would be expected since such comparisons are being made between a racemate which may contain both diastereoisomers and an optically active substance which is presumably a single stereoisomer.

The recognition of No. 75 as γ-hydroxyvaline now makes its isolation relatively easy. An extract of 128 gm. of lyophilized crowngall tumours from *K. daigremontiana* was evaporated to remove ethanol and was partitioned between water and chloroform to remove pigments. The aqueous layer was made acid (1 *N*) with hydrochloric acid and hydrolysed in the autoclave for an hour to form the lactone. The hydrolysate was filtered, evaporated to remove excess hydrochloric acid and then passed through an excess of 'Dowex'-50 in the ammonium form. Since the resin in this state retains only bases, the basic lactone, along with arginine and lysine, is retained. The column is eluted with 2 *N* ammonia and washed with water, then the eluate, boiled to hydrolyse the lactone and remove ammonia, is passed again through the same column. Again the bases are retained, but the γ-hydroxyvaline, now present as the neutral amino-acid, passes through and may be collected free of contaminating amino-acids. Following this procedure, 186 mgm. of crude product (melting at 215° C.) yielded 146 mgm. of recrystallized product (melting point 228° C.). A second crystalline form, decomposing at 248° C., may also be obtained under certain conditions. The pure product showed a specific optical rotation of (+) 10 deg. ± 0·5 deg. in water at 20° C.

Unknown No. 75 is therefore recognized as (+) γ-hydroxyvaline, but final and complete determination of structure awaits comparison with the optically active synthetic stereoisomers; in this respect, γ-hydroxyvaline presents the same problem as other new hydroxyamino-acids mentioned above.

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O-acetylhomoserine in *Pisum*

HOMOSERINE is now known to occur somewhat abundantly in the vegetative parts of pea plants[1,2], in which it is supposed to arise from aspartic acid[3], though it is said to be absent from the seed[2].

During the chromatographic examination of alcoholic extracts of the various organs of the plant, namely, leaf, stem, root and fruit, the presence of a substance reactive to ninhydrin but unstable in acid was noted. This substance proved to be present most abundantly in the pea pod, that is, the pericarp, of this leguminous fruit. It disappeared when the extracts were subjected to mild acid or alkaline hydrolysis. The then unidentified substance was referred to by Grobbelaar[4] as unidentified substance No. 200, and by Steward, Zacharius and Pollard[5] in their summary of the new nitrogenous constituents of plants as No. 84.

The relative positions of this substance, and of homoserine, known to occur in *Pisum*, on chromatograms, are shown in Fig. 1. When the lactone of homoserine is also present, as when homoserine is treated with acid, it appears as a diffuse 'streak' moving faster than homoserine in the phenol direction. The instability in acid of the unidentified substance, and the fact that it yielded, on hydrolysis, only one ninhydrin-reactive substance (homoserine), led to the first recognition of this substance as a derivative of homoserine, other than the lactone.

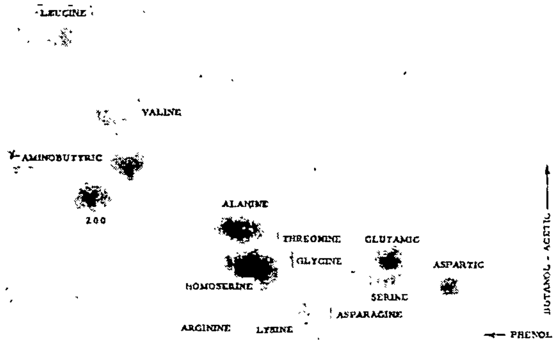


Fig. 1. Two-directional chromatogram, treated with ninhydrin, of the alcohol-soluble nitrogen compounds of *Pisum sativum* (copied from original photograph in colour)
No. 200 is O-acetylhomoserine, reacts violet. Under the conditions used, serine and glycine, asparagine and lysine were distinguishable by their colour reactions. Certain weak unlabelled spots are not positively identified

While a small amount of the substance in question was obtained from alcoholic extracts of pea shoots by paper chromatographic methods of Mueller[6], 35 mgm. of crystalline material were obtained from an extract made of the pea pods, from 4·5 kgm. of commercial peas. After clarifying the extract with basic lead acetate, lead was removed by hydrogen sulphide and the extract was evaporated at room temperature. The crystalline product was separated from the other constituents of the extract by the general method of Hirs, Moore and Stein[7]. Other attempted procedures of fractionation and isolation (absorption of the amino-acids on basic or acidic resins with the subsequent use of the appropriate eluting agent) failed, either because they were ineffective in separation or because this labile substance was decomposed. The procedure finally adopted was as follows.

The clarified pea extract was fractionated on a 15-cm. 'Dowex'-50 column, and the unknown substance emerged along with the neutral and acidic amino-acids. The acidic amino-acids were removed from the mixture, using an '*IR-4B*' column. Further successive treatments of the mixture on 'Dowex'-50 columns led to a final product contaminated only with some threonine, serine and proline. The final purification was accomplished on a cellulose-powder column (7 cm. × 65 cm.) by chromatography with *N*-butanol, acetic acid and water (9 : 1 : 2·9 by volume). The desired substance emerged from the column only slightly contaminated with proline. All the fractions which contained the substance desired were concentrated under reduced pressure at room temperature, yielding a small residue of yellowish substance. On solution in water, a waxy, insoluble, ninhydrin-negative material was discarded. The yellow aqueous solution was treated with activated charcoal, filtered through 'Celite', and the nearly colourless filtrate was concentrated *in vacuo*. By addition, drop by drop, of absolute ethanol, crystallization started and continued at low temperatures, and finally, by the addition of an excess of ether, 35 mgm. of crystals were obtained, washed with ether and dried over calcium chloride.

Despite the slight contamination with proline, evident even in the crystalline material, the elementary analysis corresponded to an acetylhomoserine (found C, 45·01 ; H, 6·80 ; N, 8·90 ; calculated for $C_6H_{11}NO_4$, C, 44·71 ; H, 6·88 ; N, 8·69 per cent).

Since the analysis does not distinguish between the N-acetyl derivative and the O-acetyl derivative of homoserine, both these substances were prepared from DL-homoserine. The methods adopted for these syntheses were as follows.

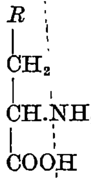
O-acetylhomoserine was unequivocally synthesized from an authentic sample of DL-homoserine by the method of Sakami and Toennies[8], as, in fact, Matsuo, Rothstein and Greenberg[9] have also reported.

For the preparation of the N-acetylhomoserine, the method of du Vigneaud *et al.*[10] was employed. Neither the N-acetylhomoserine so synthesized nor any other N-acetyl amino-acids tried (glycine, alanine, methionine and valine) reacted with ninhydrin on paper. This eliminated any possibility that the natural product was the N-acetyl compound.

In addition to the elementary analysis, the identification of the amino-acid in pea plants as O-acetylhomoserine then follows from the following chromatographic evidence in phenol and butanol–acetic solvents: (1) the product as isolated was identical with that present in the crude extract of peas; (2) the isolated and synthetic products behave identically on chromatograms and toward ninhydrin; (3) the hydrolytic products in acid and alkali obtained from the synthetic and isolated substances also behave identically on chromatograms and toward ninhydrin, and these are recognizable as homoserine and, in acid solution, its lactone which, in turn, were also tested chromatographically in other solvents (collidine–lutidine; pyridine–toluene).

As in the other cases referred to in the preceding communication, there still remains the problem of the final stereoisomeric configuration of the natural substance. Until the synthetic product is resolved, or is prepared from homoserine of known stereoisomeric configuration, the use of physical methods of comparison (infra-red analysis, etc.) is not conclusive. In fact, the configuration of natural homoserine in plants still remains to be established, since this evidence was not furnished in the paper by Miettinen *et al.*[1]. Although this final step remains to be carried out, the evidence here reported nevertheless establishes the occurrence of an O-acetylhomoserine as a new, free, natural substance in pea plants.

To conclude, it is interesting to note the structural relations between acetylhomoserine and certain other natural compounds which can be treated as substituted C4 amino-acids. All these contain the structure



$$\begin{array}{l} R \\ | \\ CH_2 \\ | \\ CH.NH_2 \\ | \\ COOH \end{array}$$

where *R* has the structure indicated in the compounds named below:

(*a*) if *R* is CH_3 the compound is γ-aminobutyric acid;
(*b*) if *R* is $CH_2.OH$ the compound is homoserine;
(*c*) if *R* is CHO the compound is aspartic-β-semialdehyde;
(*d*) if *R* is COOH the compound is aspartic acid;
(*e*) if *R* is $CH_2.NH_2$ the compound is α,γ-diaminobutyric acid;
(*f*) if *R* is CH_2OAc. the compound is O-acetylhomoserine;
(*g*) if *R* is $CH_2O.NH.CNH.NH_2$ the compound is canavanine;
(*h*) if *R* is CH_2ONH_2 the compound is canaline.

A similar series of compounds can be visualized in the next higher homologues; of these, however, only the members corresponding to the following possibilities are well known, namely: (*c*) = glutamic semi-aldehyde; (*d*) = glutamic acid; (*e*) = ornithine; and for these three the metabolic inter-relationships are well worked out, with proline being the related cyclic compound. In the C4 series, azetidine-2-carboxylic acid now appears as the cyclic compound which bears a similar relationship to the appropriate members of the C4 series[11].

It is interesting also to note that the substance γ-hydroxyvaline of the preceding communication differs from homoserine only by a methyl substitution or the β-carbon.

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AUXINS AND THEIR EFFECT ON THE GROWTH OF UNICELLULAR ALGAE

Effect of Ethanol and Auxins on the Growth of Unicellular Algae

THE effect of auxins on unicellular algae has been the subject of numerous papers, but many of the reported findings contradict each other as to whether and how the auxins affect these organisms[1–3]. We re-examined this problem because algae, if they responded to auxin, would be ideal organisms for the study of the biochemical basis of this stimulation. Some of the earlier observations may be explained by the present communication, in which we report a stimulation of growth by ethanol in several unicellular algae.

Chlorella vulgaris (*A.T.C.C.* 11468) was cultured at *p*H 6 in medium I of Hutner *et al.*[4] with a ten-fold increase in sodium dihydrogen phosphate and the addition of 1·2 gm. per litre potassium nitrate. Growth assays were conducted essentially as described by Hutner *et al.*[5]. Growth was estimated by measuring the optical density of the cultures at 440 mμ in a Klett–Summerson colorimeter, since preliminary experiments had shown a linear relation between optical density and cell counts carried out with a hæmocytometer. Carbon analyses were carried out by oxidation in potassium dichromate–sulphuric acid and measurement of the absorption at 440 mμ. A

Table 1. The Effect of Addition of Ethanol on the Growth of *C. vulgaris*

Parts of alcohol added, v/v	Optical density, 440 mμ	Sum	Range
None	110, 111, 104	325	7
1 : 5 × 10⁶	127, 112, 107	346	20
1 : 10⁵	121, 120, 113	354	8
1 : 5 × 10⁴	137, 122, 142	401	20
1 : 10⁴	186, 183, 166	535	20
1 : 5 × 10³	104, 100, 135	339	31
1 : 10³	10, 12, 12	34	2
Sum of ranges			108

Factor for 5 per cent risk = 0·70 ; 108 × 0·70 = 74

Table 2. The Effect of Addition of 1 : 10,000 parts Alcohol (v/v) on the Carbon Content of *C. vulgaris* Cells

The amount of alcohol added equals 0·4 mgm. carbon per flask

	mgm. carbon found in cells per flask	Sum	Range	Average
No addition	0·27, 0·40, 0·34, 0·34	1·35	0·13	0·34
1 : 10,000 alcohol	0·62, 0·48, 0·66, 0·57	2·33	0·14	0·58
Sum of ranges			0·27	

Factor for 5 per cent risk = 1·63 ; 1·63 × 0·27 = 0·44.

dichromate solution which had been completely reduced with sodium sulphite served as a blank. The difference in absorption of the sample from that of unreduced dichromate solution is a linear function of the carbon content. Statistical analysis was carried out by Link and Wallace's method of allowances.

Table 1 shows the effect of very small ethanol concentrations on the growth of *C. vulgaris*. An approximately two-fold stimulation of growth is observed. Since this stimulation occurred at extremely low ethanol concentrations, it was of interest to establish whether the stimulation was due to the utilization of the ethanol as a carbon source by the cells. Table 2 describes the results of an experiment in which the carbon content of the cells from media containing ethanol is compared with that of cells grown with no added carbon sources. It can be seen that the gain in carbon content can be accounted for from the amount of carbon added in the ethanol. The fact that such small concentrations of ethanol have such a marked growth-stimulatory effect can be explained if it is realized that carbon dioxide is the growth limiting factor under the assay conditions in most of the earlier experiments. When this limitation is removed, as, for example, by placing the cultures on a shaking apparatus, the stimulatory action of ethanol is lost. As could be expected, low concentrations of ethanol also stimulated the respiration of *Chlorella* when measured in a Warburg apparatus in the dark.

Recently, several reports have appeared[6,7] which describe beneficial effects of low concentrations of ethanol in higher plant systems which were being used for auxin studies. In our system no stimulatory effect could be found in the presence or absence of added ethanol, using a number of different auxins and anti auxins at concentrations from 10^{-7} to 10^{-4} *M*. Similar results were observed in experiments using *Euglena gracilis* strain *z*, *Coccomyxa simplex* (*A.T.C.C.* 11471), *Chlorella pyrenoidosa* (*A.T.C.C.* 11469), *C. ellipsoidea* (*A.T.C.C.* 11466) and *Scenedesmus obliquus* (*A.T.C.C.* 11457).

Many of the earlier papers on the effect of auxins on algae did not specify how the auxin solutions were prepared, and the possibility that ethanol was used cannot be excluded. Brannon and Bartsch[8] used alcoholic solutions upon the advice of Dr. Zimmermann, one of the early authorities in the growth-substance field, and their results very closely resemble those presented in Table 1.

Further work now in progress will attempt to define experimental conditions under which the stimulation of algal cell division would be sufficiently large to afford the use of this system for biochemical studies.

We wish to acknowledge the able technical assistance of Miss Barbara A. Edwards.

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Ethanol as a Carbon Source for the Growth of *Chlorella vulgaris*

During studies of the effect of β-indolylacetic acid on the growth of *Chlorella vulgaris*, Brannon No. 1, cultured in darkness at 25° C., evidence has been obtained that ethanol is active as a substrate for the heterotrophic growth of this organism. β-Indolylacetic acid was incorporated in certain experiments by the use of a stock solution, prepared as described by previous workers[1,2] and containing 100 mgm. β-indolylacetic acid and 2 ml. 95 per cent ethanol per litre. Glucose was used as carbon source and the inorganic salts were supplied as a Craig and Trelease[3] solution modified by using ferric ethylenediamine tetraacetate as the iron source, by addition of molybdic acid (0·017 mgm./l.), and by adjustment of the *p*H to 5·0. The activity of ethanol was detected when the alga was supplied with sub-optimal levels of glucose (for example, 0·02 per cent) (Table 1). The greater final yield, both in cell numbers (hæmocytometer count) and in algal dry weight (dried at 80° C. for 24 hr.) resulting from addition of ethanolic β-indolylacetic acid was not reproduced by equivalent concentrations of aqueous β-indolylacetic acid and occurred under conditions where the glucose was completely depleted from the medium by the alga (glucose estimated colorimetrically using a modification of Wager's method[4]) (Table 2). Increases of 0·117 (Table 2) and of 0·199 mgm./ml. algal dry

Table 1. The Effect of the Ethanol Content of the β-Indolylacetic Acid Solution on the Growth of *Chlorella vulgaris*, Brannon 1, cultured in the dark on Media containing 0·02 and 1·0 per cent Glucose

Initial population 100 cells/mm.³

Ethanol addition	Cells/mm.³ after 268 hr.	
	With 0·02 per cent glucose	With 1·0 per cent glucose
No addition	9,600	38,440
0·2 ml./l.	12,950	36,620
0·6 ml./l.	24,770	38,380

Table 2. THE EFFECT OF 20 MGM./L. β-INDOLYLACETIC ACID ADDED AS AN ETHANOLIC AND AS AN AQUEOUS STOCK SOLUTION ON THE GROWTH IN 240 HR. OF *Chlorella vulgaris*, BRANNON 1, CULTURED IN THE DARK IN MEDIUM CONTAINING 0·02 PER CENT GLUCOSE

Initial population 100 cells/mm.^{3}

Addition	Cells/mm.^{3}	Algal dry weight (mgm./ml.)	Glucose utilized (mgm./ml.)
No addition	8,150	0·275	0·2
20 mgm./l. β-indolylacetic acid aqueous	9,230	0·268	0·2
20 mgm./l. β-indolylacetic acid ethanolic (0·4 ml. ethanol/l.)	20,150	0·392	0·2

Table 3. ETHANOL AS SOLE SOURCE OF CARBON FOR THE GROWTH OF *Chlorella vulgaris*, BRANNON 1, IN THE DARK

Initial population 100 cells/mm.^{3}

Carbon source	Cells/mm.^{3} after 240 hr.
1·0 per cent glucose	31,050
1·0 per cent ethanol	1,550
0·5 ,, ,,	1,450
0·1 ,, ,,	24,450
0·05 ,, ,,	19,000
0·01 ,, ,,	13,250

weight resulted in separate experiments from the addition of 20 mgm./l. β-indolylacetic acid as a solution containing about 0·316 mgm. ethanol/ml. ≡ 0·165 mgm. ethanol-carbon/ml.).

This enhancement of growth by ethanol was only observed when the culture medium contained limiting concentrations of glucose; with 0·02 per cent glucose the growth-curves (cells/mm.^{3}) in presence and in absence of ethanol were superimposed for the first 90 hr. of culture, but beyond this time the cultures receiving ethanol continued active growth while the control cultures entered the stationary phase. The optimum concentration of ethanol when used as sole carbon source was at or below 0·1 per cent (about 0·02 *M*) (Table 3); at 0·5 per cent, ethanol inhibited cell division as compared with the carbon-omitted control.

Ethanol is actively respired by this strain of *Chlorella*, giving a rate of uptake of oxygen in the Warburg flask of 24·7 μl./10^7 cells/hr. (averaged over 22 hr.) with 0·05 *M* ethanol as compared with 43·8 μl./10^7 cells/hr. with the optimum glucose concentration (0·028 *M*). With an initial population of 4 × 10^3 cells/mm.^{3} and 2·5 ml. suspending medium, the respiratory quotient with 0·02 per cent glucose remained at or slightly above 1·0 during a 24 hr. test although, due to sugar depletion, the rate of uptake of oxygen fell to a very low level by 18 hr. Addition at 12 hr. of ethanol to give a concentration of 0·08 per cent depressed the respiratory quotient during the period 12–24 hr. to give an average value of 0·35, and during the period 18–24 hr. the respiratory quotient was almost zero, oxygen uptake proceeding with almost no evolution of carbon dioxide.

Methanol is the only other alcohol, from a number that have been tested in our laboratory, which promotes growth and respiration when supplied as sole carbon source to our strain of *Chlorella*. It is of very low activity and promotion of growth and respiration only occurs over a narrow concentration range. Increase in number of cells over the control from which carbon was omitted was 3–4 per cent (0·025 *M* methanol) of that occurring in 1 per cent glucose, whereas ethanol supports growth-rates up to 75 per cent of those in glucose. In a direct comparison, the stimulation of uptake of oxygen was, with methanol (0·05 *M*) 16 per cent and with ethanol (0·05 *M*) 53 per cent of that in 0·028 *M* glucose.

A marked stimulation of growth from the addition of ethanol has also been observed with cultures of *Chlorella vulgaris*, Pratt, growing at 26° C. in inorganic medium and receiving at their under surface 350 lux from daylight fluorescent tubes. The culture vessels were 100 ml. wide-mouthed conical flasks. These contained 50 ml. medium, inoculated with 100 cells/mm.^{3}. 'Aerated' cultures received, in a fine stream of bubbles, about 20 ml./min. of a mixture of 95 per cent air and 5 per cent carbon dioxide for 1 hr. every 24 hr.; 'non-aerated' cultures were gently agitated once a day to disperse the cells. Under both experimental conditions ethanol stimulated growth (Table 4). The cell densities obtained in the 'aerated' cultures were much higher than could be achieved under the most favourable conditions of 'dark' culture adopted. The very great increase in cell number resulting in these 'aerated' cultures from the addition of 'ethanol' has not yet been examined in terms of carbon increase. Marked stimulation of growth could also be obtained by supplying glucose to these illuminated cultures.

Table 4. THE EFFECT OF ETHANOL ON THE GROWTH OF *Chlorella vulgaris*, PRATT, CULTURED IN FLUORESCENT LIGHT (350 LUX)
Initial population 100 cells/mm.^{3}

Addition	'Non-aerated' cultures after 240 hr.	'Aerated' cultures after 192 hr.	
	Cells/mm.^{3}	Cells/mm.^{3}	Algal dry weight mgm./ml.
No addition	4,000	41,000	0·86
0·01 per cent ethanol	5,500	46,500	0·90
0·05 ,, ,,	9,400	58,000	1·14
0·10 ,, ,,	16,500	72,000	1·3
0·20 ,, ,,	11,500	114,500	1·76
0·30 ,, ,,	6,500	—	—
0·35 ,, ,,	—	139,200	2·21
0·40 ,, ,,	4,600	—	—
0·50 ,, ,,	2,400	101,500	2·55

Brannon[1] concluded that the ethanol introduced into his media was probably removed during autoclaving for 30 min. at 15 lb./in.^{2}. We have not reproduced Brannon's media but have found that our medium, containing initially 0·5 per cent ethanol, still gives a reaction for alcohol (assessed colorimetrically following oxidation to acetaldehyde with potassium bichromate–sulphuric acid) after autoclaving for 60 min. and that such media support, as a result of the ethanol addition, a significantly enhanced growth in illuminated 'non-aerated' cultures. These results not only raise the question of how far the presence of ethanol has been responsible for earlier reports of the stimulation of the growth of *Chlorella* by auxins but also suggest that the metabolism of ethanol in this organism should be the subject of further study.

A more detailed account of some of the results referred to here will be published elsewhere.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Effect of Heat Treatment on the Sintering of 'Active' Ceramic Oxide Powders

In recent years much attention has been paid to the preparation of 'active' oxide powders by decomposition of compounds; the oxide powders obtained in this way are agglomerates of fine crystallites, have high surface area and show enhanced sintering characteristics compared with the highly calcined powders normally used[1]. With pure powders prepared in this way, variations have been noted in the sintering behaviour which are difficult to account for.

It has now been found that in the sintering of compacts of these oxide powders, intermediate heat treatment at a temperature lower than the normal sintering temperature significantly increases the final bulk density. Two conditions are necessary to benefit from the effect: (1) The calcination of the original compound, such as the hydroxide before pressing, should be carried out at an optimum temperature, for example, with beryllium between 1,000° and 1,250° C. Compacts made from powder calcined at lower temperatures crack excessively on sintering, whereas the particle-size of powder calcined at higher temperatures is too large for appreciable densification to occur. (2) The pressed compact should be annealed at or near the calcination temperature of the powder and at successively higher temperatures to the temperature at which the rate of densification is high enough for the maximum bulk density to be reached in a reasonable time. In the annealing treatment, weld junctions are formed between the particles in contact in the pressed powder and the fine pore structure of the pressed compact is retained until the temperature is reached at which the rate of sintering becomes rapid. If the annealing treatment is omitted and the compact rapidly raised to the maximum temperature, uncontrolled shrinkage occurs within the agglomerate particles and these separate within the compact to form fissures and pores too large to be eliminated afterwards. The final bulk density is therefore much lower.

As an example, compacts made from beryllium oxide (BeO) prepared by calcining the hydroxide to 1,250° C. sinter to bulk densities of 2·2 gm./c.c. (that is, 27 per cent porosity) if rapidly heated to 1,600° C. in 1 hr. If similar compacts are heat-treated for several hours at 1,300–1,400° C. prior to the temperature being raised to 1,600° C., bulk densities of 2·75 gm./c.c. (that is, 8 per cent porosity) are obtained.

Confirmation of the hypothesis put forward to explain this effect has been obtained by applying an external pressure at high temperatures to the compact. Here the particles are prevented from separating at the points of contact by the external pressure, and high bulk densities result in all cases, independently of the heat treatment.

A fuller account of this work will be published elsewhere.

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Investigation of the Ionosphere using Signals from Earth Satellites

I propose to discuss some possible effects of the ionosphere on the radio signals from artificial satellites on the basis of my theoretical results[1].

The occurrence of focusing of radio waves from the point antipodal to the observer could probably be demonstrated from measurements of Doppler frequency shift (Fig. 1*a* (i)). Let *O* denote the position of the observer, *S* the satellite, *Z* and *N* the points on the orbit of the satellite in the observer's zenith and nadir. Let the critical frequency f_c of the ionosphere increase from *Z* to *N*, where it attains a value slightly greater than the transmission frequency, f_0, of the satellite. Neglecting the presence of the Earth, the trajectories of ray paths and the corresponding Doppler curve are shown in Fig. 1*a* (i) and (ii), using dotted and continuous lines for the free-space and ionospherically propagated cases respectively. When the satellite moves from a typical point *K* to *N*, the frequency received via the free-space path increases slowly to the value f_0 transmitted by the satellite. In the ionospheric case, however, the frequency will remain nearly constant at a value f_K

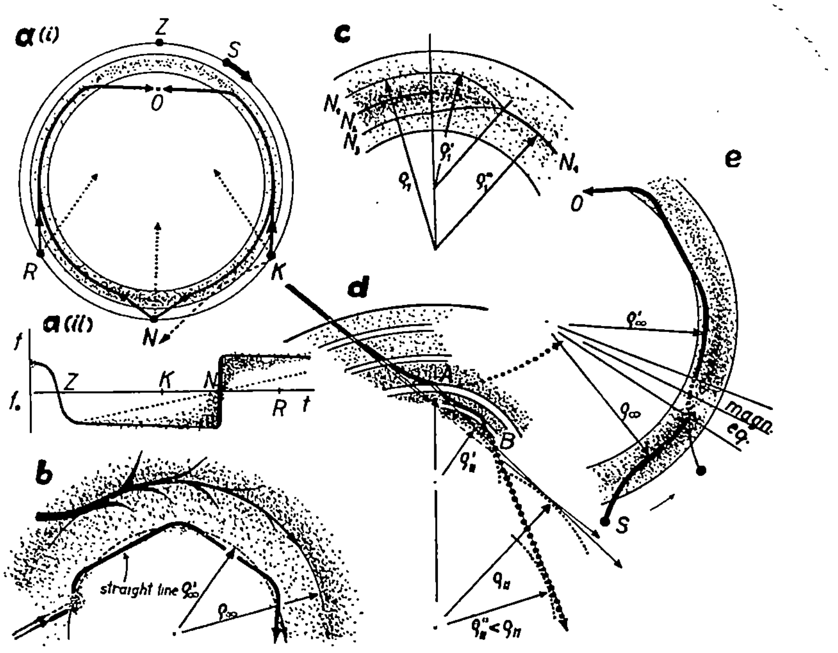

Fig. 1

until N is reached, after which the received frequency will rise suddenly to a value f_R, given by : $f_R - f_0 = f_0 - f_K$. In the vicinity of N, transmission of the signal over all possible great circle paths towards the antipodal point Z will occur. In this case all frequencies between f_K and f_R will be received. If reception occurred only within a narrower frequency band, this would indicate that propagation was effective only in a certain preferred range of directions. The maximum probability of multi-path propagation between S and O occurs when the satellite passes N.

Various theoretical modes of long-distance propagation around the Earth will now be discussed. It can be shown[2] that perpetual propagation of radio waves around the Earth in a conventional spherically symmetrical ionosphere is possible if :

$$\frac{d\mu}{d\rho} = -\frac{\mu}{\rho}$$

where μ denotes radio refractive index and ρ the radial distance. Provided the ionospheric critical frequency is smaller than the satellite frequency f_0, there usually exist two levels in the ionosphere which fulfil this condition. One of these critical levels, lying close below the maximum of electron density (denoted in Fig. 1*b* by ρ_∞), does not support stable propagation, since the smallest inhomogeneity of electron density will produce a considerable divergence of rays in all directions. The lower critical level (denoted by ρ'_∞) can support more stable propagation since small inhomogeneities will only cause the wave to oscillate along this critical level. On the other hand, to realize this desired propagation from S to O, there must always exist two suitable inhomogeneities, one to bring the ray from higher levels to this critical level and the second to take it down to the ground-level. The most probable mode of long-distance propagation seems to occur when a slight increase of electron density occurs along the ray path. Then a ray just passing the upper layer, but going so nearly tangentially that it cannot attain the surface of the Earth, can be trapped between the two levels. Let a further variation of altitude, electron density or thickness of the layer change the height of both reflecting levels (see the $\mu\rho$-diagram of ref. 2) ; when the lower one in effect falls to the surface of the Earth, the signal can be received.

Another mode of long-distance propagation by means of the ionosphere is possible, theoretically. Consider a layer the electron density of which decreases slightly in the horizontal (Fig. 1*a* (i) and *c*). Then an almost tangential ray, which in a layer with perfect spherical symmetry would usually be reflected, could pass farther into the ionosphere ; for a suitable decrease of f_c, long-distance propagation could then be realized. The penetration of the ray deeper into the ionosphere is best shown by reference to Fig. 1*d*. Suppose that the ionosphere is composed of a number of regions of finite thickness and uniform electron density separated by infinitesimally thin regions of zero electron density. According to ref. 1, so long as the layer traversed has perfect spherical symmetry and no horizontal variation, the ray is in the un-ionized regions tangential to the sphere designated by $\rho_\parallel$, concentric with the Earth's surface. At the point A, where the contour of constant electron density ceases to be spherical and decreases in radius of curvature, the ray must be tangential to a sphere of smaller radius $\rho'_\parallel$ in the intermediate un-ionized regions. Thus a ray approaching the ionosphere almost tangentially will not be reflected, but will pass through the layer very obliquely, covering a large horizontal distance.

Also the reported discrepancy[3] between the times of closest approach deduced from Doppler and direction-finding measurements might have other causes than an inclination to the horizontal of the lower boundary of the layer. It could be explained by an increase or decrease of the maximum electron density in some horizontal direction. The displacement of the centre of curvature of the contours of constant electron density from the plane of propagation could result in a considerable azimuthal deviation of the ray.

In long-distance propagation of satellite signals, an important part seems to be played by the deep local minimum of electron density usually present at the magnetic equator (Fig. 1*e*). The ray running along the ionosphere is bent slightly towards the Earth and after passing this electron density minimum is bent back to the horizontal direction. In this way it could easily attain even the stable 'critical level'. (Direct reflexions between Earth and ionosphere are not, in the early morning hours, very probable on 40 Mc./s. as the decrease of critical frequency towards the polar regions is usually very rapid, and the wave would pass through the ionosphere into space.)

Theoretically, all these modes of propagation from the antipodal point are thought to be possible on 40 Mc./s., although in practice none of them will appear frequently. A satisfactory answer to the question of what mode of propagation is preferred could probably be given by a detailed study of the Doppler curves, of direction-finding measurements and the variation of band-width of the received signal when the satellite is deep below the optical horizon.

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Horizontal Drift Measurements in the Ionosphere near the Equator

MEASUREMENTS of horizontal drift in the ionospheric E- and F-layers have been made regularly at Ibadan (magnetic latitude 2½° S.) since June 1957. These measurements are of importance in view of the theory of the origin of such drifts put forward by Martyn[1]. According to this theory, a phase reversal of the east–west component of drifts in the F-region should occur at latitudes 35° N. and 35° S. Confirmation of this phase reversal has been obtained by Purslow[2] and Rao and Rao[3] at Singapore and Waltair (India) respectively. Martyn's theory further predicts that at the magnetic equator the westward drift in the F-layer during the daytime should be of the order 200 m./sec., about twice that obtained in temperate latitudes.

The method used to measure horizontal drifts at Ibadan is similar in principle to that originated by Mitra[4], using a pulse transmitter and three spaced receiving aerials. The aerials are half-wave dipoles at 2·4 Mc./s. and are spaced at the corners of a right-angled triangle with its hypotenuse in the magnetic north–south plane, and with sides of length 127 m., 127 m. and 180 m. A film speed of about 20 cm./min.

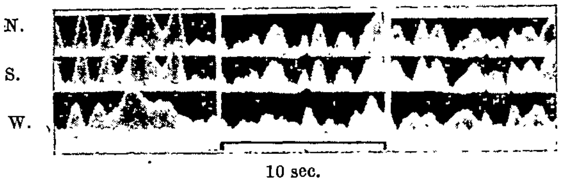

Fig. 1. Sample drift record

is normally used, and a typical film record obtained is shown in Fig. 1. E-layer drifts are measured using a frequency of 2·4 Mc./s. and F-layer drifts with a frequency of 5·7 Mc./s.

The normal method of analysis of drift records consists in measuring time-shifts between pairs of records. A simple calculation then yields the drift velocity. It is assumed in this method that the amplitude pattern on the ground remains constant in detail as it moves and that it is statistically isometric so that its statistical properties show circular symmetry. If the second assumption is not true, considerable error will arise in the apparent direction of the drift.

It is seen in Fig. 1 that at Ibadan the amplitude-fading records for the north and south aerials are almost identical and that there is no measurable time-shift between them. The record from the west aerial is similar in form but displaced in time relative to those from the north and south aerials. This strongly suggests that the amplitude pattern on the ground is elongated in the north–south direction, and an analysis of the type developed by Phillips and Spencer[5] has been made on representative records. Phillips and Spencer showed that an amplitude pattern in which the irregularities are on the average anisometric can be represented to a first approximation by a 'characteristic ellipse' representing a contour of equal auto-correlation. The axial ratio and angle of orientation of this ellipse can be obtained by a laborious process involving the calculation of the cross-correlation functions between the different pairs of aerials. This calculation is best done by means of an electronic computer, and we are indebted to the Cavendish Laboratory, Cambridge, for the analysis of certain records using the EDSAC. Other records have been separately analysed by one of us (J. H.) and the results of both analyses are summarized in Table 1.

Table 1

Layer	Mean axial ratio	Mean angle of orientation of major axis in deg. E. of magnetic N.	No. of records analysed
E	5	0°	24
F	11	0°	24

The orientations of the major axes of the ellipses are almost without exception within a few degrees of magnetic north–south and the mean orientation for both E- and F-layers is less than one degree from the magnetic meridian. There is evidence that the anisometry is more pronounced in the F-layer than in the E-layer, the mean axial ratios of the characteristic ellipses being 11 and 5 respectively. However, the values are widely distributed and, with the limited number of values at present available, no great significance should be attached to the actual values 11 and 5.

Comparable results are rather scarce and somewhat contradictory. Spencer[6], at Cambridge, using a radio stellar technique, has reported the presence of irregularities in the F-layer elongated by a factor of at least 5 : 1 along the Earth's magnetic lines of force. Phillips and Spencer[5], however, found that the axial ratios were usually less than 1·5 in the E- and F-layers for the cases that they examined using the pulse reflexion method. They also found that there was no preferred direction for the axes of the ellipses. Purslow states in a private communication that, at Singapore, axial ratios of about 2 : 1 are obtained. It is difficult to reconcile this large difference between the results at Singapore and Ibadan, which are stations of similar latitude.

The effect of the north–south elongation of the amplitude pattern is to mask the meridional components of drift. The true direction of drift can be obtained from the full correlation analysis, but this is a laborious process even with the aid of a computing machine. The east–west component, however, can be obtained from a consideration of time shifts between the fading records at the north–south and west aerials. Results have been analysed in this way for about 25 complete days in August and September 1957. Figs. 2a and 2b show the mean diurnal variation of the east–west component of the drift velocities in the E- and F-layers respectively. It is seen that in both layers the drift is towards the west during the daytime and towards the east at night, in agreement with the predictions of Martyn's theory, and in opposite phase to that found in temperate latitudes. Harmonic analysis of the F-layer data brings out the predominant 24-hr. period component. It is found that the east–west velocity, $V_{E\text{-}W}$, can be represented by the function:

$$V_{E\text{-}W} = -10{\cdot}5 + 111\sin(t + 68^\circ) + 26\sin(2t + 54^\circ) \quad \text{(m./sec.)}.$$

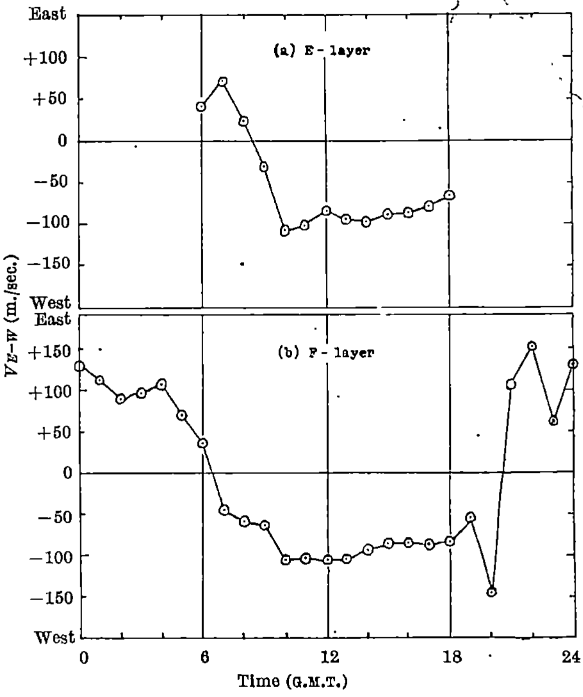

Fig. 2. Diurnal variation of east–west drift component (a) in the E-layer and (b) in the F-layer

This may be compared with Purslow's results[2] for Singapore, and Rao and Rao[3] for Waltair:

$$V_{E\text{-}W} = 1\cdot 7 + 88\sin(t + 59^\circ) + 3\sin(2t + 210)$$
(m./sec.) Waltair (autumn).

$$V_{E\text{-}W} = 18 + 45\sin(t + 84^\circ) + 22\sin(2t + 38^\circ)$$
(m./sec.) Singapore.

It is seen that the phases of the 24-hr. components are similar at the three stations although there is considerable variation in the amplitudes.

The westward daytime drift velocity in the F-layer of about 105 m./sec. at Ibadan is smaller than that predicted by Martyn (200 m./sec.), but it should be remembered that Ibadan is not placed directly beneath the centre of the equatorial 'electrojet' current. The velocity at Ibadan is larger than those at Singapore and Waltair, which are themselves farther from the magnetic equator. It is quite possible that larger velocities would be obtained at stations a few hundred kilometres north of Ibadan.

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A Man-made or Artifical Aurora

At 1051 G.M.T. on August 1, 1958, Mr. J. G. Keys, observer-in-charge at Apia Observatory, latitude 13° 48′ S., longitude 171° 46′ W., witnessed at Apia a manifestation which was at first thought to be a display of the aurora australis but is now believed to be due to a nuclear bomb explosion in the upper atmosphere. The occurrence of an auroral display in the tropics is always of unusual interest to geophysicists because of its exceeding rarity. In particular, the Aurora Australis has been reported at Apia on one occasion only, and then only in association with the severe magnetic storm of May 13–16, 1921. This display was described in detail by Angenheister[1] and Angenheister and Westland[2].

The display seen by Keys is of more than usual interest because of the extraordinary effects associated with it. Briefly, his description of the manifestation is as follows.

The display was first observed on August 1 at 1051 G.M.T. with bright rays in the western sky extending from bearing 235° and bearing 286° where the altitude of the rays was 12°. On the bearing of 235° the rays disappeared behind coconut trees at an altitude of 10·5°. It is inferred that the rays extended towards the southerly horizon. This manifestation persisted for about 6 min., then gradually diminished to a red glow centred on a bearing of 247°. This glow faded completely at 1105 G.M.T. The rays were at first violet, covered with reds and gradually changed to greens. There was a crimson arc with centre elevation 32° on a bearing of 340° and this gradually faded. Three or four red bands were seen with their centres approximately due south at an elevation of about 30–40°, and these faded rapidly. The night sky was clear with one-eighth cumulus cloud at 2,500 ft., and the moon was just past full. Associated with these manifestations were radio fade-outs which lasted from one to several hours.

Keys noticed a most unusual pronounced sudden commencement on the Apia normal and rapid run magnetograms covering the time of the above described manifestation, and sent copies to me. At 1050 G.M.T. the Apia magnetograms showed pronounced sudden commencement with reverse impulse *ssc**, and for the 3-hr. period 0900–1200 G.M.T. the K-index was 6. The Amberley (latitude 43° 09′ S., longitude 172° 43′ E.) magnetograms show no extraordinary effects and in particular no sudden commencement with or without reverse impulse.

The sudden commencement recorded at Apia is itself most unusual because of its form, which was similar to that which one would expect at a high-latitude station near the auroral zone, and not its usual simple form. The occurrence of sudden commencements with reverse impulse *ssc** is comparatively rare at Apia, and when they do occur the reverse impulse has a very small amplitude. In this case, the reverse amplitude was comparatively large and well defined. The sudden commencement in the D trace at Apia is usually very small, seldom exceeding a minute or two. In this case the amplitude of the sudden commencement in D was 9 min. The magnetic disturbance lasted about an hour and seems to have been superposed on a minor bay disturbance which was already in progress before the sudden commencement.

Auroræ, when seen in tropical regions, have always been associated with severe world-wide magnetic storms. The Amberley magnetograms show that at the time in question there was no severe magnetic storm in progress except a bay type of disturbance with K-index 3. A comparison of the Amberley and Apia magnetograms shows definitely that the magnetic disturbance recorded at Apia was not world-wide but appeared to be localized in the Central Pacific area.

If an aurora australis had been seen at Apia it should have been seen low down in the southern sky. In the manifestation described above, rays were seen in the western sky and a crimson arc was seen at an altitude of 32° in the northern sky. It was unlikely that the manifestation was the aurora borealis because Apia lies well to the south of the equator and no world-wide severe magnetic storm was in progress.

The abnormal directions in which the manifestations were seen, as well as the abnormal magnetic effects recorded at Apia, point to the fact that it was not a normal auroral display.

Approximately at the time of the sudden commencement recorded at Apia, American scientists exploded a nuclear bomb high in the upper atmosphere, at a height of 100 miles according to newspaper reports—over Johnston Island. There seems to be little doubt that the unusual magnetic effects recorded at Apia are related to this explosion and that the manifestation seen at Apia was a man-made or artificial aurora due to a nuclear explosion in the upper atmosphere.

A study of the effects due to this explosion may throw considerable light on the theory of magnetic storms and auroræ. It would be of great interest to know whether other magnetic stations in the

Central Pacific recorded similar abnormal magnetic effects.

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Emission Spectrum of N_2O+

IN the course of a study of the luminescence of gases irradiated by X-rays (to be published), some unknown bands were observed from nitrous oxide. All the other gases studied emit well-known band systems, usually of the parent gas or its ion. Gases at pressures between 1 and 700 mm. were irradiated with soft X-rays (45 kV. peak) from a beryllium-window tube, and the spectra photographed or scanned with a photomultiplier through a Hilger *D*.96 *f* 2 quartz spectrograph. The emission from nitrous oxide consisted of the unknown bands at about 3680, 3540 and 3380 A. and the nitric oxide β system (the bands in the $v' = 0$ progression between $v'' = 3$ and 13 were observed). The latter system has been observed previously as fluorescence from nitrous oxide irradiated with vacuum ultra-violet light[1]. The two sets of bands differ in their dependence on pressure; the β bands suffer little collisional deactivation at high pressures whereas the new bands are strongly 'quenched', but they must be much more strongly excited since the intensities are roughly comparable at 600 mm. Since carbon dioxide excited by X-rays emits CO_2+ bands ($^2\Sigma_u - {}^2\Pi_g$, ref. 2, and $^2\Pi_u - {}^2\Pi_g$, ref. 3) and these show a similar pressure dependence, the new bands are tentatively ascribed to N_2O+. Emission by nitrous oxide (N_2O) itself is unlikely from a consideration of its excited states[4].

The observed light intensity was very small (8-hr. exposures with $\frac{1}{2}$ mm. slit-width were necessary to photograph the spectra on *HPS* plates) and the dispersion low (100 A./mm. at 3500 A.) so the bands could not be properly characterized with this apparatus. Therefore an attempt to excite the bands in a discharge tube was made. If the identification is correct, they should appear in the negative glow; low current density and rapid flow of the gas would be necessary to reduce the decomposition of nitrous oxide which occurs in the discharge.

The discharge tube was a T-shaped 'Pyrex' tube, with $\frac{3}{4}$ in. internal diameter, 2 in. long aluminium tube as cathode and a smaller aluminium tube in a side-arm as anode; nitrous oxide was pumped through the tube from cathode to anode; spectra were photographed through a silica window with a Hilger medium quartz spectrograph. The positive column in the side tube was coloured green or pink (first positive bands of molecular nitrogen); the cathode glow was blue. The new bands appeared in the cathode glow and behaved as expected. A detailed study of the excitation conditions was not made, but the best conditions seemed to be 1 mm. mercury pressure and minimum discharge current (8 m.amp.). The bands also appeared at higher pressures (3–4 mm.); though more current was needed (50 m.amp.), the flow rate was probably higher. The nitrogen second positive and first negative systems and the nitric oxide β and γ systems were also present; the nitrogen bands were of comparable intensity with the new bands and may have obscured some of them. A better separation from these emissions from decomposition products of nitrous oxide would probably be obtained at higher rates of flow.

Table 1. WAVE-LENGTHS AND INTENSITIES OF THE NEW BAND SYSTEM

(A.)	I	(A.)	I	(A.)	I
3380	*S*	3595	*MS*	3773	*WM*
3396	*S*	3611	*M*	3823	*M*
3429	*W*	3626	*W*	3843	*S*
3434	*W*	3636	*WM*	3864	*S*
3454	*MS*	3653	*MS*	3874	*W*
3470	*MS*	3661	*M*	3928	*W*
3481	*W*	3673	*MS*	3961	*W*
3493	*M*	3687	*VS*	3981	*W*
3516	*MS*	3706	*VS*	4008	*WM*
3521	*M*	3720	*W*	4030	*WM*
3541	*VS*	3746	*MS*	4126	*W*
3558	*VS*	3764	*WM*	4225	*W*

The band heads and estimated intensities are listed in Table 1. A number of very weak bands were also observed and probably belong to this system; the strong bands were clearly degraded to the violet. Though further evidence is required, the most likely emitter of these bands seems to be N_2O+. Further study of them would be of interest for comparison with the isoelectronic CO_2+ (refs. 2 and 3) and NCO (ref. 5).

I wish to thank the U.K. Atomic Energy Authority for a research fellowship, during the tenure of which this work was carried out.

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Abnormally High Fatigue Strengths in Aluminium Alloy Extruded Bar

IN 1932, Matthaes[1] reported that the tension properties of aluminium alloy extrusions in the longitudinal direction were significantly greater than in the transverse direction, and it is now well known that both the ultimate tensile stress and proof stress values may be 20–30 per cent greater than the respective values for rolled or forged material. However, it has been observed[2] that the fatigue properties are little affected by the extrusion process. In view of this the following results are of interest.

Unnotched and notched rotating cantilever fatigue tests at 12,000 cycles/min. have been conducted on two batches of aluminium alloy extruded bar, one of 0·510 in. diameter to specification *S.A.A.*(*E*)2*D*.649 (24*S*-*T*) and the other of 0·750 in. diameter to specification *D.T.D*.683/3 (75*S*-*T*), both batches being of Australian manufacture.

Table 1 shows that the tension properties of both batches are far in excess of the specification properties for these alloys. Fatigue tests using specimens of 0·300 in. nominal test diameter have indicated that the materials exhibit several unusual characteristics.

In Fig. 1 are shown the mean *S*–*N* curves for specimens of the 24*S*-*T* material; these are also typical of

Table 1. TENSION PROPERTIES OF THE EXTRUDED ALLOYS

	0·1 per cent proof stress (lb./sq. in.)	0·2 per cent proof stress (lb./sq. in.)	Ultimate tensile strength (lb./sq. in.)	Elongation (per cent)	Hardness (B.H.N.)
Spec. *S.A.A.(E)2D.*649 (minimum)	38,000	40,000	63,000	12	—
(as received)	60,000	62,000	86,000	13·5	141
24*S–T*4 (typical)	—	49,000	69,000	18	120
Spec. *D.T.D.*683/3 (minimum)	67,250	—	78,500	7	—
(as received)	81,500	83,750	93,000	8	172
*D.T.D.*683 (typical)	82,500	—	90,000	10·5	170

the *D.T.D.*683. The unnotched curve was obtained using specimens finished by diamond turning, while the notched specimens were machined by plunge cutting with a form tool. Notch radius was 0·080 in., giving a theoretical stress concentration factor of approximately 1·5. For these materials the unnotched fatigue strengths at 10^8 cycles are about 50 and 80 per cent greater respectively than typical values quoted for the two alloys, that is, approximately 30,000 lb./sq. in. compared with 20,000 lb./sq. in. for the 24*S-T* and approximately 42,000 lb./sq. in. compared with 23,000 lb./sq. in. in the case of the *D.T.D.*683.

Fig. 1 also shows that the notched fatigue strength at 10^8 cycles (approximately 25,000 lb./sq. in. for each alloy) is likewise higher than might be expected, but more remarkable is the unusual shape of the curve. Notched specimens, particularly those tested at high nominal stresses, tended to give a 'conical' type of fracture, a good example of which is shown in Fig. 2. This type of fracture is similar to that reported by Vitovec[3] after applying a high static preload to a notched fatigue specimen.

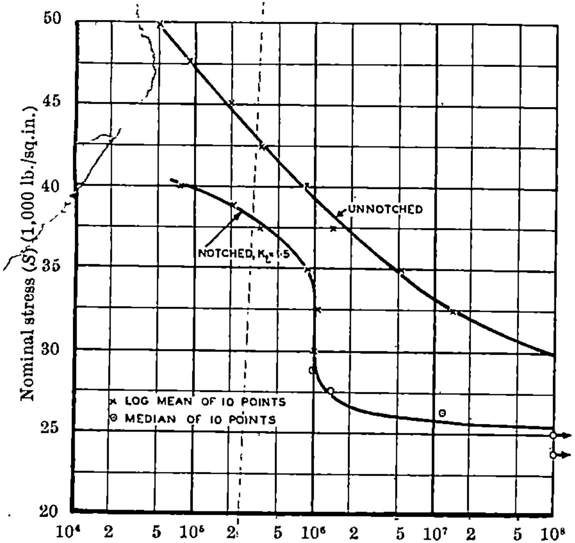

Fig. 1. Fatigue curves for 24*S-T* aluminium alloy

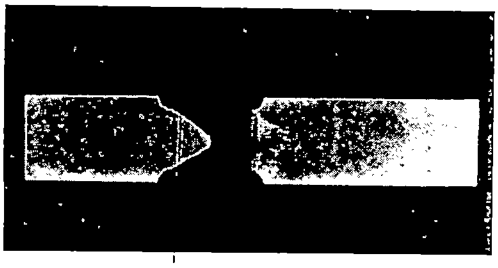

Fig. 2. Longitudinal section through fractured 24*S-T* notched fatigue specimen, radius 0·080 in.

Metallographic examination of the alloys has indicated a marked directionality effect along the length of the bars, but at this stage no other unusual characteristics have been observed.

A possible explanation is that the abnormal characteristics in these materials may be associated with some peculiar extrusion texture, and that this has caused significant modifications in the mode of precipitation in the alloys. In view of the practical implications of the high properties observed, it is intended to make a more detailed investigation of these materials.

This work forms part of a programme on the fatigue of aircraft materials being conducted at the Aeronautical Research Laboratories in Melbourne. Acknowledgment is made to the Chief Scientist, Australian Defence Scientific Service, Department of Supply, Melbourne, Australia, for permission to publish this communication.

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A Phosphatic Band underlying Bauxite Deposits in Jamaica

IN 1957, during a detailed examination of the bauxite deposits in Jamaica, suggested by Dr. D. A. Bryn Davies, managing director of Alumina Jamaica, Ltd., and sponsored by that Company, I noticed the occurrence of a hitherto unrecorded sedimentary band separating red bauxite from underlying white Tertiary limestones. The band is extremely local in occurrence. So far as at present known, it is only typically developed within a limited area around the Kirkvine Works of Alumina Jamaica, near Mandeville, and at Grove Place, about 4 miles to the north-west. It is known to be absent in many other areas. It has, however, certain interesting characteristics which may have some bearing on the history and age of the bauxite deposits. For this reason, and because it may lead to the recording of other occurrences in Jamaica, or even in association with the similar bauxite deposits in Haiti and the Dominican Republic, it seems worth placing on record the following summary account. It is intended to include a more detailed description in a later general account of the bauxite deposits.

In nearly all the occurrences examined, the band was found to be very thin and inconspicuous. It seldom exceeds one foot in thickness, and it is often only one inch or less thick. It tends to be lenticular in habit, and is discontinuous within the limited area in which it has so far been recognized. In spite of its thinness, it may include several layers or laminæ differing in composition, or in appearance.

As a whole, the band has the following distinctive chemical characteristics:

(1) It is often highly phosphatic, some layers consisting almost entirely of white collophane.

(2) Spectrographic examinations carried out by Aluminium Laboratories, Ltd., at Arvida, Quebec; by Mr. C. O. Harvey, in the Chemical Laboratories of the Geological Survey, London; and, at the suggestion of Dr. A. Muir, in the laboratories of the Soil Survey Division, Rothamsted Experimental Station, Harpenden, England, disclosed the presence of a considerable number of rare or uncommon elements, including silver, barium, beryllium, cadmium, cobalt, chromium, copper, nickel, lead, strontium, tin, yttrium, zinc and zirconium. While most of these are present only in minor or very minor amounts, some, notably zinc, cadmium, beryllium and yttrium, were found to be present in surprisingly high concentrations in certain samples.

(3) The band is radioactive to an extent appreciably greater than the overlying bauxite. Determinations made in the laboratories of the Atomic Energy Division of the Geological Survey, London, on ten different samples of sediment gave results indicating a content of radioactive matter ranging from 0·006 to 0·028 (average 0·0145) per cent U_3O_8 equivalent, that is, quantitatively, the radiation detected is equivalent to that which would be emitted if the stated amount of U_3O_8 were present in the rock, to the exclusion of other radioactive elements. No attempt has been made as yet to determine what element or elements cause the radiation. Mr. S. H. U. Bowie, chief geologist of the Division, informs me that the figures obtained by his staff during a survey of radioactivity in Jamaica indicate the radioactivity of the bauxite to be about one-twentieth of that of the most active of the phosphatic sediments.

A further characteristic of the phosphatic band is that it is fossiliferous, the organic remains consisting almost entirely of very small (< 10 mm.) fish teeth. A large collection of these teeth was submitted to Dr. E. I. White, keeper of palæontology in the British Museum (Natural History), who states that the assemblage is definitely marine, and includes teeth of small carcharinid sharks, chaetodonts, sparids, labrids (wrasse) and scarids; but it is not possible on the basis of the material submitted to assign a more definite age than Tertiary (or later) to the assemblage.

It may be added that a few specimens of teeth were tested for radioactivity, and gave a result indicating 0·008 per cent U_3O_8 equivalent.

The above characteristics of the sedimentary band, taken as a whole, suggest that it should be classified as a marine phosphorite, comparable in general character with, for example, the marine phosphorites of the Bone Valley formation in Florida. If this comparison can be sustained, the Jamaican deposits probably represent the attenuated and re-sorted remnants of a once more extensive phosphorite deposit, younger than the karstified white limestones (Upper Eocene to Lower Miocene) on which it rests. Deposition may have taken place during the submergence of Jamaica in Plio-Pleistocene time. I have seen evidence of submergence at heights at least 1,500 ft. above present sea-level, and Butterlin[1] records marine terraces in Haiti up to a height exceeding 2,000 ft. (630 metres).

A further point of interest is that the known occurrences of the phosphatic sedimentary band lie on the margin of an area within which there are several deposits of bauxite with an abnormally high phosphate content. The evidence so far available, however, is insufficient to determine whether or not there is any interdependence between the occurrences of phosphatic sediment and the distribution of high-phosphate bauxite.

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Electron Transfer and Thermal Racemization of Ethylenediaminetetraacetato-cobaltate(III)

IN general, electron-transfer reactions which involve no net chemical change have been studied by the use of isotopic tracers. In 1950, Dwyer and Gyarfas[1] reported that the mixing of *d*-tris(2,2′-bipyridine)-osmium(II) with *l*-tris(2,2′-bipyridine)osmium(III) was followed by the very rapid loss of all optical activity. This was explained by assuming that a rapid electron transfer process led to redistribution of the dextro and lævo configurations among the two oxidation states. Consequently, Dwyer and Gyarfas suggested that optical activity should pro- vide a second convenient method for the study the kinetics of electron-transfer processes.

Prior to the investigations reported in th munication, systems of this type which h examined were found to be either too rapid detailed study[2], or very poorly reproducibl D. H., and Stratton, W. J., unpublished re

The system:

$$[\text{Co-III (EDTA)}]^- - [\text{Co-II (EDTA)}]$$

has been found convenient for the detailed s electron transfer by means of optical activit ceeding at an easily measured rate, wit reproducibility. Adamson and Vorres[3] inve isotopic transfer in this system, and the co complex has been resolved into its optical antipo (Dwyer, F. P., private communication, provides best method of resolution). Since the cobalt(II) complex is configurationally unstable, electron transfer should be accompanied by racemization, as indicated in the following equation:

$$d\text{-}[\text{Co-III (EDTA)}]^- + [\text{Co-II (EDTA)}]^{2-} \rightleftharpoons [\text{Co-II (EDTA)}]^{2-} + l\text{-}[\text{Co-III (EDTA)}]^-$$

Although *d*-$[\text{Co-III (EDTA)}]^-$ is optically stable at room temperature, it does racemize[5] at 100° C. Consequently, a second path for racemization might be observed in accordance with the equation:

$$d\text{-}[\text{Co-III (EDTA)}]^- \rightleftharpoons l\text{-}[\text{Co-III (EDTA)}]^-$$

Reproducible results have been obtained indicating that the hexadentate complex *d*-$[\text{Co-III (EDTA)}]^-$

undergoes racemization at 100° C., and that this racemization process is catalysed by the cobalt(II) complex. The concentrations of the cobalt(III) complex and of the cobalt(II) complex have been varied, as has the ionic strength. The pH was maintained in the region $2{\cdot}0 \pm 0{\cdot}2$. The expected pseudo-first-order kinetics in rotation were observed in accordance with the expression:

$$-\ln(\alpha/\alpha_0) = Rt$$

where α is the rotation at any time t, α_0 is the rotation at zero time, and R is the pseudo-first-order rate constant.

The integrated rate law accounting for these two paths is:

$$-\ln(\alpha/\alpha_0) = 2(kb + k')t$$

where k is the second-order constant associated with electron-transfer process, k' is the rate constant for thermal racemization, and b is the concentration of [Co-II (EDTA)]$^{2-}$. Equating coefficients of t in the experimental and theoretical rate equations gives the equation:

$$R = 2kb + 2k'$$

From the linear dependence of R on b, k and k' are [illegible]ted to be $1{\cdot}4\ M^{-1}$hr.$^{-1}$ and $0{\cdot}015$ hr.$^{-1}$, re[illegible]y. Direct determination of k' also gives an [illegible]value of $0{\cdot}015$ hr.$^{-1}$ for five experiments [illegible] zero concentration of cobalt(II) complex. [illegible]ults reported by Adamson and Vorres[3] were [illegible]d at 60°, 70° and 85° C. Extrapolation of [illegible] 100° C. gives $2{\cdot}1\ M^{-1}$hr.$^{-1}$ as the value [illegible]cond-order rate constant. It can be shown [illegible] defined here, corresponds to one-half the [illegible]ived from the McKay equation for electron [illegible]sotopic method). Consequently, the value [illegible] here ($1{\cdot}4\ M^{-1}$hr.$^{-1}$) should be compared [illegible]alf the value reported by Adamson and [illegible]amely, $1{\cdot}1\ M^{-1}$hr.$^{-1}$. These studies will be [illegible]d in greater detail at a later date.

[illegible]pport of this research by the National Science [illegible]ndation, Washington 25, D.C., is gratefully [illegible]knowledged.

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Electronic Configuration d^4 in a Complex Ion

BECAUSE of the instability of the valence states which transition metal atoms must possess in order to have four non-bonding electrons remaining after forming a d^2sp^3 octahedral complex ion, few simple ions of this configuration have been studied. This lack of experimental data has seriously hindered the elucidation of the properties to be expected for a complex ion of this type[1].

In this laboratory we have recently measured the magnetic susceptibilities of the potassium hexahalo-osmates-IV, K_2OsF_6, K_2OsCl_6 and K_2OsBr_6, and recorded their ultra-violet and visible spectra (200–750 mμ) and their infra-red spectra (2–33μ). Johannesan and Lindberg[2] previously reported that $(NH_4)_2OsBr_6$ exhibited a paramagnetism independent of temperature which they explained on the basis of Kotani's[3] theory of spin-orbit coupling. Nyholm *et al.*[4] have recently shown that the same ideas can be applied to K_2OsCl_6. In both the above cases, a reasonably good agreement with theory is obtained for the magnetic properties of these compounds, if one invokes a rather large amount of spin-orbit coupling, $A = 6{,}400$ cm.$^{-1}$.

We have found that this large amount of spin-orbit coupling will also explain the observed visible spectra for K_2OsCl_6 and K_2OsBr_6 when the predictions of Kotani's theory are combined with certain results from ligand field theory.

In Kotani's theory the spatial degeneracy of the three t_{2g} orbitals is removed, and the resulting levels have energies $-A/2$, $-A$, and $A/2$ cm.$^{-1}$ respectively. If one considers transitions from these 'perturbed' levels to an anti-bonding e^*_g orbital, the counterpart of the bonding molecular orbital constructed from the d_{e_g} orbital of metal atom and the e_g orbital of the ligand, a reasonable explanation of the absorption spectra results. One finds peaks which differ in energies by approximately the amounts which the t_{2g} orbitals are perturbed via spin-orbit coupling. The energy difference between the lowest t_{2g} orbital and the e^*_g orbital (10 Dq) decreases regularly from $OsF_6^{=}$ to $OsBr_6^{=}$, as one would predict due to the decreasing strength of the crystal fields.

Unfortunately, the magnetic results obtained for K_2OsF_6 do not fit a Kotani-type curve, and hence it is difficult to evaluate the spin-orbit coupling constant. It is interesting to note that the visible spectrum of this material differs markedly from that of the others, containing only two bands, one at 50,000 cm.$^{-1}$ and one at 32,467 cm.$^{-1}$ [5], and also that this material is a light yellow compound while K_2OsCl_6 (wine-red) and K_2OsBr_6 (black) are both deeply coloured materials.

It would be interesting to see if other complex ions of the heavier transition metal atoms possess an absorption spectrum which can be explained by the utilization of the spin-orbit coupling concept. These three materials, together with $(NH_4)_2OsBr_6$, are (to our knowledge) the only known examples of paramagnetic substances independent of temperature among the complex ions of the platinum group elements.

The details of the above work and a more complete discussion of the theoretical aspects of the problem will be published soon.

We would like to acknowledge the many helpful discussions with Dr. James Richardson and Dr. J. M. Honig. One of us (A. G. T.) wishes to acknowledge the financial assistance of the Purdue Research Foundation and the Research Corporation for the years 1956 and 1957.

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An Anodal Threshold Phenomenon in the Squid Giant Axon

The action potential of nerve or muscle is an all-or-none response when preceded by a critical decrease in transmembrane potential. Previous investigations[1-3], on the other hand, have indicated that for hyperpolarization by anodal (inward) currents the membrane's properties are a continuous function of current. I wish to report, however, that in a potassium-enriched medium the squid giant axon displays a discontinuous rise in membrane potential for a sufficiently intense anodal current and that this behaviour is, in several respects, similar to that of the action potential.

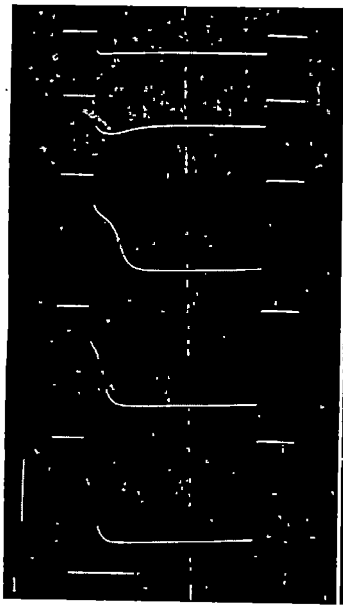

Fig. 1. Changes in transmembrane potential associated with increasing intensities of anodal current. Reading from top to bottom, the current densities (m.amp./cm.^{2}) are 0·079, 0·110, 0·115, 0·120, 0·126, respectively. The vertical and horizontal bars subtend 50 mV. and 50 msec., respectively. Axon No. 1 ; temperature, 21° C.

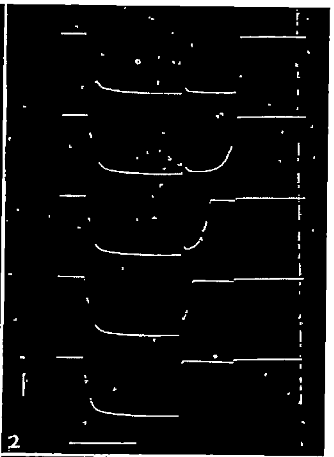

Fig. 2. Application of short cathodal pulses of increasing (top to bottom) intensities during a suprathreshold response. The vertical and horizontal bars subtend 50 mV. and 50 msec., respectively. Axon No. 2 ; temperature, 22° C.

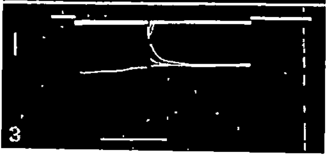

Fig. 3. Composite record made during repetition (1/sec.) of 130 msec. anodal pulse superposed upon which is a brief anodal pulse (see text for details). The vertical and horizontal bars subtend 50 mV. and 50 msec., respectively. Axon No. 3 ; temperature, 21° C.

The present results were obtained from axons immersed in a solution of 400 mM potassium acetate, 0·6 mM potassium bicarbonate, and sufficient sucrose to maintain tonicity. Fig. 1 shows the change in transmembrane potential recorded at the midpoint of a 17-mm. length of axon across the membrane of which pulses of various intensities of anodal current were passed. A graph of steady-state potential as a function of current consists of two distinct straight lines both extrapolating close to the origin, indicating that for the present medium the threshold change is a discrete decrease in membrane conductance (in the case illustrated the ratio is 0·29 : 1). A long relative refractory period (associated with an increase in conductance relative to that of the resting membrane) follows the 'excited' state : repetitition of the same pulse within a period of less than 1½ min. fails to elicit the suprathreshold response (there is no such refractoriness for subthreshold currents).

That this response represents a discontinuity in the current-voltage (I–V) relationship (when examined with pulses of constant current) and not merely a region of high dV/dI is illustrated by Figs. 2 and 3, in which short cathodal and anodal pulses, respectively, superimposed on the main response, are compared.

It can be seen that following the cathodal pulse the potential is stable at only one of two levels—the transition zone is 'forbidden'. (For cathodal currents the steady-state I–V curve contains no discontinuity and it is not possible to abolish a maintained depolarization with a short anodal pulse.) An analogous phenomenon for the normal threshold response (abolition by application of short anodal pulses during the action potential) has been described for the node of Ranvier[4], for the squid axon injected with tetraethylammonium chloride[5], and for cardiac muscle[6].

The converse property is demonstrated by the experiment of Fig. 3, which shows (in a composite record of approximately ten traces) the effect of the repetition (1/sec.) of a 1-msec. anodal pulse superposed midway during a 130-msec. anodal pulse (both [illegible] were of approximately the same inten[illegible] were not altered during the tra[illegible] largest prolonged downward deflex[illegible] potential recorded during the appli[illegible] the first pulse of the sequence. Th[illegible] prolonged deflexion is the response [illegible] of the next five pulses—the system [illegible] tory. As the refractoriness sub[illegible] short pulse becomes adequate to elic[illegible] the remainder of the long pulse) [illegible] threshold response as indicated b[illegible] traces with slow rising phases fol[illegible] end of the short pulse. This, agai[illegible] strates that the potential cannot be st[illegible] in the region between the sub- and s[illegible] threshold levels.

A sufficient condition for the abo[illegible] phenomenon is a concentration of potassium greater than normal irrespective of the presence or absence of calcium, sodium, or of chloride.

I am indebted to Dr. I. Tasaki for his provision of laboratory space and for the loan of some equipment. I thank Mrs. I. Tasaki for constructing the electrodes employed in this investigation.

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Formation of Condensed Tannins in Plants

I have presented evidence[1] that leucoanthocyanins are probable precursors of condensed tannins ; recent examination of *Schinopsis* spp.[2,3] supports this view (see also ref. 4). It was shown[1] that most of the soluble phenolic materials in the sapwood of *Eucalyptus marginata* were leucoanthocyanins, and that the amount increased at the sapwood–heartwood boundary, where they were changed into the insoluble 'tannins' characteristic of this species. In some samples containing a distinctive outer heartwood zone, this change in solubility was found to be incomplete. Monomeric leucoanthocyanins which yielded delphinidin and cyanidin were found in this zone but were not observed in the inner heartwood.

When the ray and vertical parenchyma cells die at the sapwood–heartwood boundary, increased amounts of tannins appear and are liberated into the surrounding tissues. It is significant, therefore, that the ray parenchyma cells only of Douglas fir contain leucoanthocyanins[5]. This conclusion was drawn from the observation that the contents of these cells rapidly became red on the addition of concentrated hydrochloric acid. However, all the leucoanthocyanins we tested failed to behave in this manner.

We have found that the leucoanthocyanins can be made insoluble if blocks of fresh wood (*Eucalyptus* spp.) are soaked in a mixture of 40 per cent formalin/glacial acetic acid/water (5 : 15 : 80) under vacuum for 18 hr., heated for 1 hr., then boiled in water for 3 hr. When sections from these blocks were heated with butanol/hydrochloric acid (20 : 1) for 40 min., little, or no, formation of alcohol-soluble anthocyanidins occurred. After the sections were mounted in glycerol/water/hydrochloric acid (47 : 47 : 6) the contents of the parenchyma tissue in the sapwood were observed to be bright red ; but no evidence of diffusion into the surrounding tissue was seen. Because anthocyanidins were obtained from untreated specimens, and as leucoanthocyanins are almost the only compounds which become red after heating with hydrochloric acid, the colour formed in the treated sections is considered to be due to leucoanthocyanins.

The ray cells close to the cambium were lined with leucoanthocyanins (compare with the phenolic membrane substance of Erdtman[6] and the lining observed by Pew[7]). The contents of the sapwood ray cells were observed to be greater in amount at increasing distances from the cambium, assuming a clearer and brighter red colour. Only in the sapwood adjacent to the heartwood boundary did the vertical parenchyma also contain leucoanthocyanins. At the boundary and in the heartwood the fibres were red and in the case of *Eucalyptus camaldulensis* red inclusions were also observed. Those cells immediately surrounding kino veins in *Eucalyptus obliqua* were filled with leucoanthocyanins, but only small amounts were evident in the ray cells a short distance from the injury. These observations support the views of Bate-Smith and Metcalfe[8] that the materials in their wood sections reacting with iron are most commonly leucoanthocyanins (see also ref. 9) formed *in situ*.

A marked decrease in the amount of glycosides and increase in aglycones has recently been observed after the sapwoods of *Schinopsis*[2], *Prunus*[10] and *Eucalyptus* spp.[11] were changed to heartwoods. It is evident that physiological changes affect the nature of the chemical constituents. The above evidence indicates that the glycoside moieties (and probably other carbohydrates) are metabolized in the living cells of the sapwood, particularly in the region of increased activity at the heartwood boundary. Leucoanthocyanins appear to be a common product of this metabolism. Recently, it was found that the amount of (+)-catechin was much lower in the heartwood than in the sapwood of species which also contained leucoanthocyanins[2,10,12]. Consequently, it seems likely that the condensed tannins in many woody plants are formed by the polymerization of leucoanthocyanins, either alone or in conjunction with catechin and other compounds.

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Electron Spin Resonance Investigations of Rat Liver and Rat Hepatoma

Studies concerning the role of free-radical reactions in biological processes have long been hampered by the lack of a method for detecting free radicals in biological systems. The recent investigations of Commoner[1] have shown that electron spin resonance techniques offer considerable promise for this purpose. This communication describes, first, an investigation of sample preparation and handling methods, and second, a qualitative comparison of electron spin resonance signal intensities from normal rat liver tissue with Novikoff rat hepatoma.

Measurements were carried out at 9,000 Mc./s. using a magnetic field of 3,200 gauss. The g values observed were almost identical with that of the free electron. The size of all samples was approximately 1·7 gm. The free radical contents were inferred from measurements reflecting the area under the absorption curve, which is proportional to the free radical content of the samples studied.

Table 1 shows that freeze-dried rat liver samples contain about five times as many free radicals per unit weight of living tissue as samples chilled to − 196° C. instantly upon excision of the liver and examined in the electron spin resonance spectrometer without allowing the sample temperature to exceed − 130° C. at any time. Since the electron spin resonance line width of freeze-dried samples was found to be less than that of the instant-frozen samples, it is possible that the free radicals created during the freeze-drying process are artefacts, completely different from those originally present in frozen, but otherwise unaltered, material. This conclusion is supported by the fact that Miyagawa and Gordy *et al.*[2] have found that the electron spin

Table 1. Free-Radical Content of Rat Liver and Hepatoma obtained from Electron Spin Resonance Measurements carried out at −130° C.

Sample type	No. of samples	Free-radical content in molecules × 10^9/gm. wet weight*
Freeze-dried rat liver	2	10
Immediately frozen rat liver	3	1·9
Rat liver stored at 0–25° C. from 22 hr. to 2 weeks	3	1·3
Immediately frozen rat hepatoma	3	0·67

* Values given are based on an estimate of the electron spin resonance spectrometer sensitivity obtained using a 6 × 10^{-5} gm. diphenylpicrylhydrazil sample for calibration.

resonance signal from lyophilized tissue arises from sorbed molecular oxygen.

Although storage of the unaltered samples at 0–25° C. causes a reduction in electron spin resonance signal strength compared with that observed for instantly frozen samples (Table 1), no significant difference in signal amplitude was found for storage periods ranging from twenty-two hours to two weeks. Therefore, the conclusion is that some of the free radicals initially present in the instantly frozen samples are unstable at room temperature; the remainder appear to be extremely stable.

Quite possibly part of the observed electron spin resonance signal (particularly that part which is stable at room temperature) observed in frozen liver tissue is caused by the presence of certain paramagnetic trace elements. From the careful investigations of Heggen and Strock[3] it is concluded that for those paramagnetic ions exhibiting a *g* value close to 2·00, only one or two trace elements occur in large enough concentrations to contribute to the signal. However, more work is being carried out at the present time to determine to what extent such ions are affecting the signal intensities.

Investigations of hepatoma tissue were carried out using Novikoff tumour transplant material originally induced by use of diacetylaminofluorene. As seen from Table 1, the free-radical content of instantly frozen rat hepatoma is only roughly one-third of that found in similarly processed normal liver.

Thus, the number of unpaired electrons observed in frozen samples is much lower than that obtained for freeze-dried specimens. The differences in signal strength between instantly frozen rat liver and rat hepatoma is much greater than that reported by Commoner[1], who used the freeze drying process.

We wish to acknowledge many helpful discussions of this material with William H. Storey, jun., and George Pish. Dr. Karl Paschkis, of Jefferson Medical College, kindly supplied the rats having tumours.

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Detection of Polarization by Biological Organisms

For the construction of colour filters Christiansen[1] had the idea of using scattering to attenuate unwanted wave-lengths. He used a finely divided isotropic scatterer in an isotropic medium to achieve partial monochromatization. One of us (A. N. F.), in connexion with a Science Fair project on these filters, suggested the use as a scatterer of a bundle of parallel transparent birefringent fibres immersed in an isotropic medium the refractive index of which matched one of the refractive indices of the fibres. Light vibrating in a direction characterized by this index will then be transmitted unattenuated by scattering. A Patent Office search reveals a number of patents involving scattering to attenuate unwanted components[2]. However, there seems to be no recognition of this method of achieving polarized light in the scientific literature. These patents seem to have been largely overlooked.

There are a large number of papers devoted to the responses to polarized light of various biological organisms[3]. In most cases, the method used to determine the plane of polarization is not known.

We wish to suggest that the above-mentioned polarizing mechanism may well play the necessary part in such determination. Animal tissues often contain bundles of parallel transparent birefringent fibres immersed in a liquid or gel medium. If the index of refraction of the medium is other than the average of the two refractive indices of the fibres, then any transmitted light will be partially polarized. If it matches one of the refractive indices, then that component will be a maximum in intensity. We intend to search for such polarizers.

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Stable Test-Papers for Seminal Acid Phosphatase

The acid phosphatase test has proved its usefulness in seminal stain examinations and is now in widespread use[1–4]. The desirability of preparing a stable form of the reagent was obvious, more especially for 'scene-of-crime' searching, post-mortem examinations and for scientists and clinicians without laboratory facilities.

We have prepared stable test papers as follows.

200 mgm. α-naphthyl phosphoric acid and 400 mgm. diazo-*o*-dianisidine (as 'Brentamine Fast Blue *B* Salt', Imperial Chemical Industries) are dissolved in 100 ml. *M*/5 citric acid/sodium citrate buffer of *p*H 4·9. Filter papers soaked in this solution are immediately blotted and left to dry singly at room temperature. These manipulations are best carried out in light of low intensity. The papers are

then stored in opaque bottles at room temperature over calcium chloride. In use the papers are wetted with distilled or tap water and pressed against the suspected seminal stain. A positive reaction is shown by an intense purplish colour.

Discoloration on storage proceeds only slowly and we have found the papers to be usable up to a year from manufacture, with a little activity remaining up to two years (storage temperature 15° C. ± 5° C.). Storage at 55° C. for some weeks is possible, showing that temperature will not be a limiting factor for use in tropical countries.

A modification of the test is to interpose wet filter paper between the stain and the test-paper instead of placing them in direct contact. This possesses the advantage of reducing contamination of the seminal stain by the reagent (this is especially important where serological tests are afterwards to be applied): it permits also the use of test papers which, although discoloured by long storage, are still usable. This is because extracts from the stain and test paper pass into the clean filter paper and react there. The insoluble coloured decomposition products remain on the test paper.

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Detection of Hæmoglobin, Hæmoglobin–Haptoglobin Complexes and other Substances with Peroxidase Activity after Zone Electrophoresis

HÆMOGLOBIN and complexes of serum haptoglobins with hæmoglobin, have peroxidase-like activity which permits their detection in small amounts. For this purpose benzidine[1,2], *o*-tolidine[2], guaiacol[3] and leucomalachite green[4] have been employed. However, none of these substances has proved entirely satisfactory. The colours given by benzidine and tolidine fade within minutes[5], especially when applied to starch-gel strips, and both reagents give appreciable background staining on paper. Instability of benzidine and guaiacol colours used to detect horse-radish peroxidase after paper electrophoresis has been noted also by Jermyn and Thomas[6], who reported that *o*-anisidine, *p*-aminodimethylaniline and hydroquinone were even less satisfactory as reagents for the detection of peroxidases. Malachite green, formed from leucomalachite green, is more stable; but we have found the reagent much less sensitive than either benzidine or tolidine.

In studying the haptoglobins of human serum we have sought a more satisfactory peroxidase colour reaction and have compared a number of likely substances. The reagents in each case were prepared by dissolving 100 mgm. of the test substance in 70 ml. of ethanol and adding 10 ml. of 1·5 *M* acetate buffer (*p*H 4·7) and 18 ml. of water. Immediately before use 2 ml. of hydrogen peroxide (100 vol.) was added. The composition of the reagents was thus similar to the benzidine reagent used by Moretti *et al.*[1]. After electrophoresis, paper or starch-gel strips were placed in the reagent for 15 min. and were then washed in three changes of water.

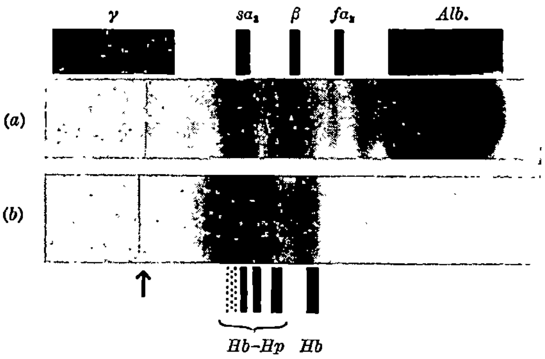

Fig. 1. Starch-gel electrophoretic strips (borate buffer, *p*H 8·6; ref. 7) of human serum containing added hæmoglobin. *a*, stained with naphthalene black to show proteins; *b*, stained with dianisidine reagent to show hæmoglobin–haptoglobin complexes and photographed after 2 weeks. *Hb*, hæmoglobin; *Hb–Hp*, hæmoglobin–haptoglobin complex. Arrow indicates point of insertion

Results are shown in Table 1 and indicate that *o*-dianisidine was the most satisfactory reagent. It gives an intense brown colour in zones having peroxidase activity. After washing and drying, the reactive areas on paper become brown-pink while the paper shows a very pale pink background. In starch-gel strips the coloured areas remain unaltered for at least a month while the background remains perfectly white. Fig. 1 illustrates a starch-gel electrophoresis strip of human serum containing added hæmoglobin.

Table 1. COMPARISON OF PEROXIDASE REAGENTS

Substance*	Sensitivity† (10^{-2} μgm./cm.^{2})	Comment
o-Dianisidine	5	Colour stable
o-Tolidine	10	Marked background colour fades in hours
Benzidine	20	Colour fades in minutes
p-Anisidine	40	Colour fades in minutes
Amidopyrine	>80	—
Leucomalachite green	>80	—
Guaiacol	>80	—

* All materials were obtained from British Drug Houses, Ltd.
† Minimal concentration of hæmoglobin detectable on paper.

While most of our experiments were carried out with hæmoglobin or with hæmoglobin–haptoglobin complexes, we have also found the dianisidine reagent satisfactory in the detection of peroxidase activity in extracts of horse-radish (*Cochlearia armoracia* L.) and other plants.

We should like to thank Miss Hania Ayzner for technical assistance in this investigation.

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Increased Survival of Rats irradiated with X-Rays and treated with Parathyroid Extract

An increase in the survival of rats irradiated with X-rays has been found when parathyroid extract is given either before or after the irradiation.

In our experiments, each rat received 200 U.S.P. units (2 ml.) of parathyroid extract (Eli Lilly) subcutaneously in the dorsothoracic region; control animals received an equal volume of normal saline. Both the parathyroid extract and the saline contained phenol as a preservative and were injected under sterile conditions. Males of a laboratory strain of hooded rats were used. They weighed 275–350 gm. at the beginning of each experiment. In one series, injections were given 12–18 hr. before irradiation. In a second series, animals were injected immediately after irradiation. All animals received 760 r. whole-body irradiation (measured in air) with 2,000 kVp. X-rays (1·5 m.amp.). This dose was given 65 cm. from the target at 400 r./min. No filters were used. Food and water were given *ad libitum* during the post-irradiation period.

When parathyroid extract was injected before or after irradiation, a difference was observed between the percentage surviving in the control and treated animals. By 20 days, this difference became highly significant (Table 1).

Table 1. Effect of Parathyroid Extract on the Number of Rats surviving 760 r. Whole-body Irradiation with X-Rays

	Days after irradiation						Percentage surviving (30 days)
	0	10	15	20	25	30	
Pretreatment (12–18 hr. before irradiation)							
Saline (2 ml.)	119	117	94	74	68	63	52·9
Parathyroid extract (2 ml.)	119	118	109	102	98	97	81·5*
Post-treatment (immediately after irradiation)							
Saline (2 ml.)	56	50	23	14	12	12	21·4
Parathyroid extract (2 ml.)	54	51	41	38	37	36	66·7*

* $P < 0{\cdot}001$ (chi-square)

When parathyroid extract was injected before irradiation, survival at 30 days irradiation was 52·9 per cent in the controls and 81·5 per cent in the treated animals (Table 1). When injections were given after irradiation, survival was 21·4 per cent in the controls and 66·7 per cent in the treated rats. This represents an increase in survival of 28·6 per cent and 45·3 per cent for rats injected with parathyroid extract before and after irradiation, respectively. These differences were highly significant ($P < 0{\cdot}001$).

Between 30 and 60 days, the difference between the percentage surviving in the controls and treated animals was still evident, although slightly reduced. The percentage surviving in the controls was 51·3 and in the treated rats was 73·1, when treatment was administered before the irradiation. In rats injected after irradiation, the corresponding percentages at 60 days were 16·1 and 57·4.

It is not clear why fewer animals survived in the control group injected with saline immediately after irradiation (21·4 per cent) than in the controls injected before irradiation (52·9 per cent) (Table 1). However, a much greater proportion of gastro-intestinal hæmorrhage occurred in the animals which died in the series injected after irradiation. This may have been the cause of the difference.

We conclude that the parathyroid extract used protects against radiation death. Experiments are in progress to determine whether this effect is a result of the activity of the hormone (that is, its ability to increase serum calcium[1]) or to some other property of the extract.

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Protective Action of Venoms containing Phosphatidase-*A* against Certain Bacterial Exotoxins

We reported recently that a fraction of venom of the Australian tiger snake (*Notechis scutatus scutatus*), rich in hæmolysin, protects mice against both the dermonecrotic and lethal action of staphylococcal alpha toxin. Such an effect is observed when this fraction of the venom is injected either together with the toxin or separately[1].

Further work has shown that protection is not afforded by the crude venom of the tiger snake, nor by a fraction of the venom rich in neurotoxin but poor in hæmolysin. On the other hand, we have observed that the crude venom of the Australian black snake (*Pseudechis porphyriacus*), of the king brown snake (*Pseudechis australis*), and of the honey bee (*Apis mellifera*) gives the same order of protection against the lethal action of staphylococcal toxin in mice as does the hæmolysin-rich fraction of the venom of the tiger snake. The former three venoms, like that of the tiger snake, are strongly hæmolytic, all containing the enzyme phosphatidase-*A* (Doery, H. M., unpublished work). Unlike the venom of the tiger snake, however, they are not powerfully neurotoxic.

By toxoiding the hæmolysin-rich fraction of the venom of the tiger snake with 0·2 per cent formalin, the ratio of the resultant toxicity to the protective power was reduced from that of the untoxoided material. A notable protection against the lethal action of staphylococcal toxin was obtained with this toxoided fraction when it was administered up to 30 min. after the staphylococcal toxin.

Further, we have observed that both this toxoided fraction of tiger-snake venom and non-toxoided crude bee venom protect mice against intraperitoneal challenge with living staphylococci, the virulence of which was enhanced by Boake's[2] method (Table 1). This finding supports evidence that death following the intraperitoneal injection of mice with such living challenge is due to the production of alpha toxin (North, E. A., unpublished work).

It is known that the products of the action of phosphatidase-*A* on lecithin are a fatty acid and lysolecithin. Further, it was shown many years ago that soaps of certain long-chain fatty acids neutralize a number of bacterial toxins *in vitro*[3].

We have confirmed these findings as regards staphylococcal alpha toxin, tetanus toxin and diphtheria toxin using either sodium oleate or sodium linoleate. We have failed to demonstrate protection with the soap of the corresponding saturated acid, sodium stearate. In addition, we have observed that

Table 1. PROTECTION OF MICE AGAINST INTRAPERITONEAL CHALLENGE WITH LIVING VIRULENT STAPHYLOCOCCI BY A TOXOIDED TIGER SNAKE VENOM FRACTION AND CRUDE BEE VENOM

Test	Protective agent	Treatment when given in relation to challenge	Route	Day of death	Survivors after 7 days
1	Nil (controls)	—	—	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	4/20
	0·02 mgm. toxoided tiger snake venom fraction	75 min. before	Subcutaneous	1 1 1 2 3 4 5	13/20
	,, ,, ,,	45 min. after	Intravenous	1 1 1 1 1 1 1 1 1 1 3 3 7	7/20
2	Nil (controls)	—	—	1 1 1 1 1 1 1 1 1 1 1 1 1 3	2/15
	0·02 mgm. toxoided tiger snake venom fraction	95 min. before	Subcutaneous	1 2 2 4 4 5 5	8/15
	1/40 of one bee sting	100 min. before	Subcutaneous	1 1 1 1 2 4 4 7	7/15

All mice were challenged intraperitoneally with 1 ml. of a suspension of living coagulase-producing *Staphylococci* the virulence of which was enhanced by Boake's (ref. 2) clotting mixture.

protection against the lethal action of staphylococcal toxin in mice may be afforded by sodium oleate administered separately. Evidence has also been obtained that the hæmolysin-rich fraction of the venom of the tiger snake is antagonistic to the action of tetanus toxin in mice.

These observations suggest a possible defence mechanism against *in vivo* action of certain bacterial toxins. Phosphatidase-*A*[4] and lysophosphatides[5,6] have been reported to exist in animal tissues as such. Long-chain fatty acids may be liberated from phosphatides in cell envelopes as a response to the action of these toxins. The nature of the suggested interaction between the bacterial toxins and the fatty acids is not understood. This work is being reported in detail elsewhere.

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Comparison of the Effect of Ultra-violet and X-rays on the Capillaries of the Frog's Web

THE web between the toes of the frog is very suitable for the examination of the primary processes in the skin after irradiation with ultra-violet light, since the very thin corneal layer permits the entry of ultra-violet light of short wave-length. The transparency is measurable and makes possible the estimation of the absorption at different wave-lengths. To compare the effects of different wave-lengths, knowledge of the absorption coefficient at the site of biological action is necessary.

Transparency measurements were carried out in the range 280–600 mμ; below 280 mμ there was no transparency. The thickness of the layers (stratum corneum on each side, its layer of compensation, Malpighian layer and the dermis in the centre) was determined in histological cross-section. We were unable to detect a significant change in the absorption coefficient for the different layers, and therefore no influence of the histological structure was observed.

Fig. 1 shows average percentage of the applied radiation absorbed by a layer 1μ thick plotted against the depth of the layer. The diameter of the field measured was 2·4 mm. Ultra-violet irradiation was supplied by a high-pressure mercury lamp[1], *HBO* 2001. The radiant flux density was measured with a bolometer.

The reactions of the blood circulation to irradiation have been studied by Giersberg and Hanke[2] and by Bücker and Hanke[3]. Together with histological effects and changes in transparency with the changing water-content of the layers, the flow of blood was blocked even though the width of the vessels remained constant. The doses which produced this effect in 50 per cent of the animals were 10 watt sec. cm.$^{-2}$ (280 and 297 mμ) and 35 watt sec. cm.$^{-2}$ (313 mμ). 366 mμ had no effect. The absorption per layer 1μ thick was 0·3 per cent at 280 mμ (Fig. 1), 0·58 per cent at 297 mμ and 0·69 per cent at 313 mμ in the region of the capillaries on the irradiated side. The relative efficiency of the different wave-lengths

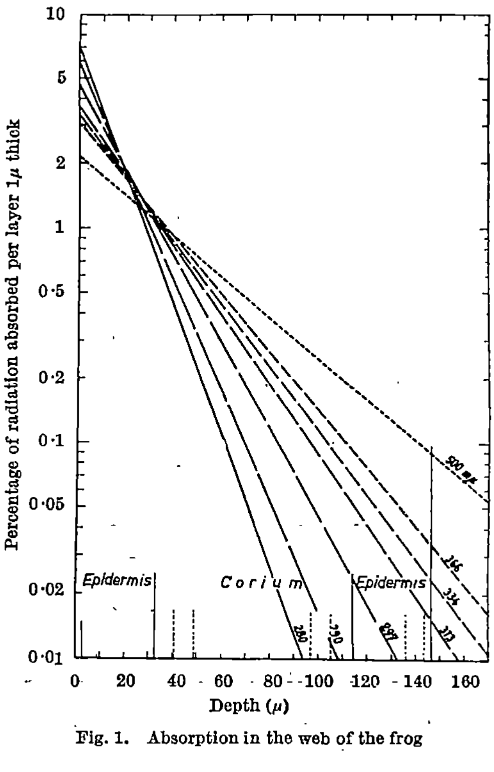

Fig. 1. Absorption in the web of the frog

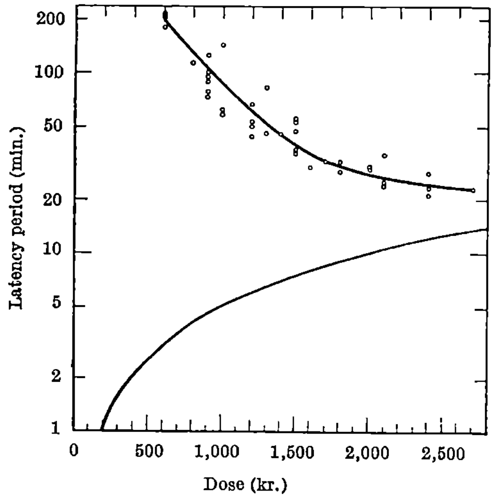

Fig. 2. Dependence of latency period on dose (upper curve). Dose-rate 200 kr./min. Curve below shows irradiation times

280, 297 and 313 mμ was 1 : 1·9 : 8. It is evident that the capillaries or their neighbourhood are the site of the primary effect.

After irradiation with X-rays ('Dermopan' apparatus, 45 kV., 25 m.amp., beryllium window, 35 mm. from tube axis, 200 kr./min.), blockage in the capillaries occurred only, after a latent period, within the limits of the irradiated field. The effect was caused by a dose of 600 kr. and more. The latent period decreases exponentially with the dose. The differences in Fig. 2 at high doses result from the longer irradiation times. The effect after X-irradiation with 1,750 kr. occurs 30 min. after the start of irradiation. Ultra-violet irradiation (297 mμ) requires a radiant flux-density of 55 mwatts cm.$^{-2}$ during 30 min. to produce stasis in 50 per cent of the animals. In these conditions the ultra-violet energy absorbed (297 mμ) at the site of its biological effect must be 35 times higher than the X-ray energy (the absorbed energy after irradiation with 1,750 kr. is 1·63 mwatt sec. cm.$^{-2}$ per layer 1μ thick; the energy absorbed in the capillary layer during 30 min. ultra-violet irradiation (297 mμ) is 58 mwatt sec. cm.$^{-2}$ per layer 1μ thick, radiant flux density 55 mwatt cm.$^{-2}$). The differences between the effects of ultra-violet light on animals are larger than those of X-rays. These differences depend on the thickness of the absorbing layers, on a yearly rhythm, and on the natural ultra-violet background. After X-irradiation the differences are small, and depend on internal factors such as blood-pressure, maintenance of blood in the capillary system, etc. The differences in the induction period are shown in Fig. 2. Histologically there are some differences between the effects of the two kinds of rays which we used[4].

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Biochemical Basis of Disturbances caused by Thermal Stress in the Central Nervous System of Man

Investigations on men subjected to thermal stress showed characteristic changes in behaviour as well as disturbances in higher nervous activity. Thermal stress at first causes increased excitability of the central nervous system, the subjects showing an augmented mobility, a vivid interest in their environment and a marked loquacity. Later, this condition undergoes a change and the subjects fall into a state of drowsiness (without, however, any tendency to sleep) and apathy[1]. Measurements of the conditioned reflex-[2] and serial reaction-time[3] revealed changes of these values under the influence of environmental high temperature.

This investigation aimed at determining the biochemical events by which such disturbances in the functions of the central nervous system are caused. Two enzymes present in blood, namely, acetylcholinesterase (true cholinesterase) of erythrocytes and cholinesterase (pseudo-cholinesterase) of plasma were investigated. The first of these enzymes is identical, or almost identical, with the acetylcholinesterase present in the central nervous system[4]. Establishment of changes in the activity of this enzyme, so important in conduction and transmission processes, could serve as at least a partial interpretation of the disturbances caused by thermal stress.

The second enzyme investigated, pseudo-cholinesterase, is present in many tissues. Its presence, among others, in the autonomic ganglia indicates a connexion with the functions of the autonomic part of the nervous system. Its exact role therein, however, is unknown. The activity of pseudocholinesterase has been investigated for the present only to detect changes caused by thermal stress.

The investigations were carried out on 50 male subjects aged between 20 and 47 years. The subjects were medically examined and considered to be healthy. The subjects were placed, naked and

Table 1

Enzyme: Substrate:		Acetylcholinesterase of erythrocytes Acetyl-β-methylcholine		Cholinesterase of plasma Butyrylcholine	
Time of blood taking		Before stress	After stress	Before stress	After stress
b_{30} per 0·05 ml. of whole blood	No. of subjects	50	50	50	50
	No. of determinations	100	100	100	100
	Mean	76·1	77·2	29·9	30·6
	Standard error	± 2·3	± 2·3	± 0·7	± 0·7
	Standard deviation	± 16·5	± 16·2	± 5·1	± 5·1
	Range	52·1–137·1	51·0–132·9	10·0–42·1	13·5–44·0

The symbol b_{30} denotes cholinesterase activity. It indicates the amount of carbon dioxide (μl.) evolved during the period of 30 min. minus the amount of carbon dioxide evolved during the same period by spontaneous (non-enzymatic) hydrolysis of the substrates (four for acetyl-β-methylcholine and three for butyrylcholine) (see ref. 7).

stretched out on the wooden floor at complete rest for 2 hr., in a climate chamber which has been described by Dutkiewicz *et al.*[5]. The activity of both enzymes was estimated with the gasometric technique exactly as described by Augustinsson[6]. Acetyl-β-methylcholine chloride ('Amechol', Savory and Moore, Ltd.) was used as substrate for acetylcholinesterase, and butyrylcholine chloride (L. Light and Co., Ltd.) for cholinesterase.

The results are shown in Table 1.

There are no significant differences in the activity of the two enzymes investigated before and after 2 hr. in the climate chamber. The results obtained agree with those of Field *et al.*[7], who also found no changes in the activity of acetylcholinesterase of brain in rabbits with pyrexia.

Investigations of the acetylcholine content in the brain hemispheres of mice exposed to conditions of thermal stress similar to those described above for our human subjects showed no differences in values obtained for animals in normal and in heated atmospheres[8]. If, therefore, it is admissible to compare experimental results obtained for men with those obtained for mice, it appears probable that cholinergic neurones and synapses are not involved in the changes in behaviour and higher nervous activity caused by thermal stress.

We wish to thank Mrs. A. Lewicka for help in performing these experiments.

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Effect of 8-Azaguanine on Antibody Synthesis *in vitro*

CREASER[1] has shown that 8-azaguanine is strongly inhibitory to induced enzyme formation in bacteria, but less so to the formation of 'constitutive' enzyme. On the basis of these findings and other evidence[1], Creaser suggested that induced enzyme formation might be mediated by unstable ribonucleic acid templates needing continuous resynthesis, while 'constitutive' enzyme formation might utilize more stable templates.

The concept has been advanced that antibody formation may be analogous to induced enzyme formation (for example, ref. 2). To gain information on this, the effect of inhibition of the incorporation of carbon-14-leucine into antibody protein and into a 'constitutive' spleen cell protein was studied. 8-Azaguanine was taken as an inhibitor particularly of nucleic acid synthesis and *p*-fluorophenylalanine as an inhibitor particularly of protein synthesis.

Spleen cell suspensions were prepared from rabbits three days after an anamnestic injection of egg albumin. The details of this preparation will be described elsewhere[3]. Since the rate of incorporation of carbon-14-leucine into antibody by the spleen cell preparation is linear for at least 24 hr.[3], this period was adopted for the measurement of antibody synthesis. At the end of the incorporation period, radioactive antibody was isolated by co-precipitation with added rabbit anti-egg albumin and egg albumin. Control precipitates, made with an unrelated antigen–antibody system (human γ-globulin–antihuman γ-globulin), yielded less than 4 per cent of the activity found in the test precipitates (egg albumin, anti-egg albumin) (Table 1). The fraction insoluble in trichloracetic acid prepared from the insoluble material recovered from disintegrated cells was used as a 'constitutive' spleen cell protein.

Table 1. THE 24-HR. INCORPORATION OF CARBON-14-LEUCINE INTO ANTIBODY

Radioactivity in medium, c.p.m. ^{14}C-DL-leucine	L-Leucine conc. (μgm./ml.)	No. of cells*	Control γ-globulin, anti-γ-globulin p.pt. Total/c.p.m.	Egg albumin, anti-egg albumin p.pt. Total/c.p.m.
$3 \cdot 9 \times 10^6$	91	6×10^7	310 208	17,400 16,600
$2 \cdot 0 \times 10^6$	59	4×10^7	530 585	14,600 15,300
$0 \cdot 8 \times 10^6$	39	4×10^7	86 89	7,000 7,700

Precipitates were washed twice with 0·85 per cent saline with 2 mgm./ml. carbon-12-DL-leucine.

* 2×10^7 cells approximately equivalent to 10 mgm. wet weight.

As is evident from Fig. 1, isotope incorporation into antibody was sharply inhibited by 8-azaguanine (solid circles). However, there was also a very considerable inhibition of incorporation into the insoluble cell protein fraction (open circles). Furthermore, the same effect was seen with *p*-fluorophenylalanine, which also inhibited incorporation into antibody (solid triangles) more than incorporation into the insoluble fraction (open triangles). *p*-Fluorophenylalanine may be regarded as a general antagonist of protein synthesis, independent in its action of any peculiar lability of a ribonucleic acid template. The differences noted in isotope incorporation into antibody and into cell protein, therefore, may better be attributed to relative rates of the respective protein syntheses rather than, particularly, to differences in turnover rates of ribonucleic acid templates. Consis-

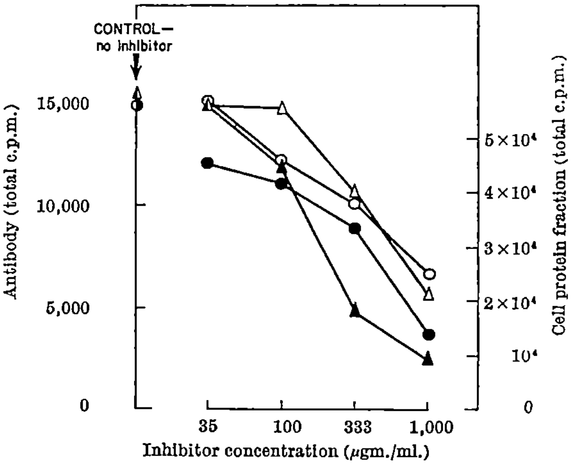

Fig. 1. Incorporation of carbon-14-leucine into antibody and insoluble cell protein fraction. Inhibition by 8-azaguanine and by *p*-fluorophenylalanine. ●—●, Antibody, 8-azaguanine; ▲—▲, antibody, *p*-fluorophenylalanine; ○—○, cell protein 8-azaguanine; △—△, cell protein *p*-fluorophenylalanine. Carbon-14-DL-leucine was added after 1 hr. of pre-incubation with inhibitors. Total counts/min. for antibody and cell protein refer to the totals produced per culture (20 mgm. wet weight)

Table 2. Inhibition of Phosphorus-32-Phosphate Uptake into Phosphate Fractions of the Cell by 8-Azaguanine and by *p*-Fluorophenylalanine

Inhibitor	Percentage of control uptake		
	Acid-soluble organic phosphate	Ribonucleic acid phosphate	Deoxyribonucleic acid phosphate
8-Azaguanine 300 µgm./ml.	70	72	53
p-Fluorophenylalanine 300 µgm./ml.	100	98	81

Cell suspensions were incubated for 1 hr. with phosphorus-32-phosphate after a 4-hr. period of pre-incubation with inhibitor.

tent with this interpretation is the finding (Table 2) that in a concentration (300 µgm. per ml.) at which 8-azaguanine has a 35 per cent inhibitory effect on antibody synthesis (cf. Fig. 1) there is a similar (30 per cent) reduction in phosphate turnover in the acid-soluble phosphate pool. Thus, though 8-azaguanine inhibits antibody formation, this is not an isolated event, but rather a manifestation of a general suppression of spleen cell function.

This tentative interpretation of the spleen cell system, however, is subject to several limitations. Amino-acid incorporation into antibody, made only in a small proportion of the cells, has been compared with amino-acid incorporation into a poorly characterized protein isolated from the whole cell population. Moreover, a considerable fraction of the latter appear to be dying[3]. Finally, in induced enzyme formation, it is the inhibition of the ability to begin making new protein which is measured, whereas, in the present system, it is the inhibition of the ability to continue to make new protein which has been measured.

Further experiments designed to approach these points are in progress. This work was supported by U.S. Public Health Services grant *E*1305.

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Distribution of Choline Acetylase in Insect Conductive Tissue

It has been clearly shown that insects contain acetylcholine, cholinesterase and choline acetylase, and the work of Smallman[1-3] has done much to evaluate these. Since then, a more specific study of the substrate and enzymes in the conductive tissue of the American cockroach, *Periplaneta americana* L., has shown that acetylcholine occurs most abundantly in the brain and ganglionic tissue of the central nervous system[4], that the amount of acetylcholine increases after treatment with anticholinesterases when the nervous system shows intense electrical activity[5], and that acetylcholine is found in blood at this time[6]. These facts are compatible with those found for vertebrates.

Table 1. Synthesis of Acetylcholine by Choline Acetylase of Cockroach Conductive Tissue

Tissue	Rate of acetylcholine synthesis (mgm./gm./hr.)
Brain	50·6
Brain + sub-œsophageal ganglion	53·0
Ganglia of thoracic nerve cord	20·8
Sixth abdominal ganglion	18·0
Thoracic nerve cord	11·4
Ventral nerve cord	10·6
Abdominal nerve cord	6·2
Connectives of the thoracic nerve cord	2·6
Fifth leg nerve	2·0
Coxal muscle	0
Flight muscle	0

A further step in the evaluation of the role of acetylcholine has now been taken by determining the distribution of choline acetylase in conductive tissue of the cockroach. This work was carried out with homogenates of tissues, as more purified enzyme preparations required impractical amounts of tissue. The activity of choline acetylase of homogenates was determined by the amount of acetylcholine formed in incubates containing coenzyme *A*, acetyl phosphate, transacetylase, choline, salts and buffer (Mehrotra, K. N., and Chefurka, W., private communication). The rate of acetylcholine formation was linear for the incubation period of 15 min., and all work was carried out at 30° C., the experimentally determined temperature optimum for choline acetylase from both cockroach and housefly. This optimum is close to that found for insect eggs (Mehrotra, K. N., and Chefurka, W., private communication). Table 1 shows the rates of acetylcholine synthesis for nervous and muscle tissue. It is at once evident that the brain and thoracic ganglia contain the highest amount of choline acetylase. The results for the distribution of choline acetylase are striking, for they compare favourably with the distribution of acetylcholine[4] in the same tissues. Furthermore, the intracellular distribution of choline acetylase appears to be similar to that found for acetylcholine. At tissue weights equivalent to and in excess of that for nervous tissue, no synthesis was found in cockroach leg muscle. This observation is of interest for, as yet, no detectable amount of acetylcholine has been found in denervated cockroach muscle[7]. The synthesis-rate for cockroach brain is the highest yet reported for acetylcholine synthesis in either vertebrates or invertebrate conductive tissue.

The importance of the functional role of acetylcholine in insects must be considered in view of this evidence for the occurrence and distribution of acetylcholine and related enzymes in the nervous system of the cockroach, and the lack of evidence for physiologically significant amounts of other neurohormones. The details of this work and observations on the tissue distribution of cholinesterase will be published more fully elsewhere.

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Metabolic Alteration in Leukæmia induced by a Virus

RECENT publications[1,2] reporting the induction of leukæmia in mice by cell-free extracts have re-awakened general interest in the role of viruses as oncogenic agents and, as a corollary, in the metabolic alterations induced by these agents. It has been shown in this laboratory that alterations in host cell metabolism induced by virus can be detected very soon after infection[3]. The current investigation was undertaken to see if analogous effects could be observed *in vivo* using one of the viruses inducing tumours. The agent investigated here was that described by Friend[2] as producing a leukæmia in mice, characterized by splenomegaly and an accumulation in the spleen of stem cells. The basic experiments were performed as follows: 150 mice were infected i.v. with 0·2 ml. of a cell-free filtrate from spleens of mice carrying the infection. 150 control mice received the same amount of cell-free filtrate prepared from normal spleen. Beginning the day after inoculation of the virus, and at the intervals thereafter indicated in Fig. 1, six infected and six control mice were selected at random and given intraperitoneal injection of 5 μc. of phosphorus-32. 3 hr. later the spleens of these animals were removed, weighed, dried in pre-weighed planchets, reweighed, the radioactivity determined, and expressed as c.p.m./mgm. dry tissue. The averaged wet-weights of the spleens from a typical experiment as well as the averaged c.p.m./mgm. dry spleen are given in Fig. 1. As part of the same experiment, on the fifth day some of the control and the infected mice received 300 r. of total body X-irradiation. The results for weight and radioactivity of the spleens of these mice examined on subsequent days are also included in Fig. 1.

It can be seen that even before spleen enlargement, the spleens in the infected animals took up more radioactive phosphorus than did those in the controls. This has been observed in four out of four experiments performed. Some variation occurred in the day-to-day uptake of phosphorus-32 by the spleens, but in the many (more than 40) observations made, the infected ones always had a higher radioactivity (as c.p.m./mgm.). The statistical significance was usually quite high; in the experiment reported here the P values for the differences between control and infected spleen uptakes was 0·005 or better. The administration of X-rays decreased the size of the infected spleens to normal, so that one could not have detected disease on the basis of spleen size alone. The uptake of phosphorus-32 was decreased in both the infected and control spleens. However, the differential between infected and their controls was as great as it was in the non-irradiated animals.

Table 1. EFFECT OF VARIOUS PATHOLOGICAL CONDITIONS ON UPTAKE OF PHOSPHORUS-32 BY SPLEENS

Condition	Average wet spleen weight		C.p.m./mgm. dry spleen weight		Percentage change
	Infected	Control	Infected	Control	
1. Lymphocytic choriomeningitis (inoculated i.p.)	116	127	248	218	14
2. Histoplasma capsulatum	503	247	285	248	13
3. Lymphocytic leukæmia transplanted	263	68	640	945	−35
4. Leukæmia *P*-195 (Hodgkin's-like), transplanted	613	187	62	62	0
Leukæmia *HE*-11,764 *G*-4, transplanted	154	147	49	44	11
Spontaneous AKr leukæmia	415	75	123	67	83
5. Gross virus-induced leukæmia	751	57	543	322	69

These animals were kindly supplied by: (1) Dr. Victor H. Haas; (2) Dr. Herbert Hasenclever; (3) Dr. Stephen O. Schwarts; (4) Dr. Lloyd Law; and (5) Dr. Ludwig Gross (ref. 1). At least six experimental and six control mice were used, and in most cases two or three such groups were used. Differences of less than 20 per cent are not considered significant.

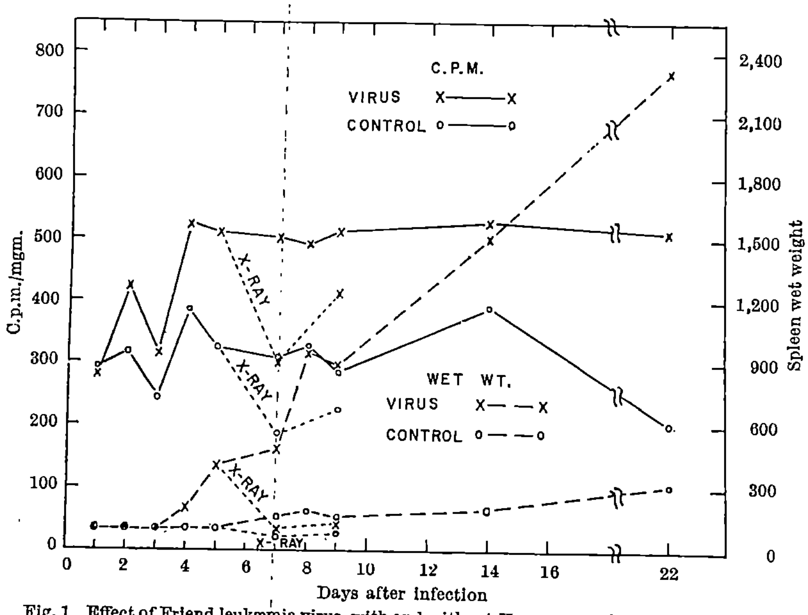

Fig. 1. Effect of Friend leukæmia virus, with and without X-rays, on uptake of phosphorus-32 by spleen

In other experiments 1 mgm. of cortisone was administered daily intramuscularly instead of X-rays. As with X-rays, the infected spleens returned to normal size, but their subsequent uptake of phosphorus-32 was accelerated over the controls as much as in those without cortisone.

In order to get some information about the specificity of the acceleration of phosphorus-32 uptake, several other diseases involving the spleen were studied in a comparable way. The disease and the uptake of phosphorus-32 by the spleens of these animals are given in Table 1. For reasons not relevant to these observations, the amount of radioactivity given was not the same for the different diseases. This accounts for the marked differences in absolute count from one disease to the next.

Table 1 demonstrates that the stimulated uptake of phosphorus-32 seen with the Friend agent is not a general phenomenen associated with spleen pathology or spleen enlargement, but is to some extent specific. It is striking that none of the transplanted leukæmias showed an increased phosphorus-32 uptake, while the spontaneous leukæmia and the other virus-induced leukæmia did. It should be recalled that some previous work with spleens of mice with transplanted leukæmia indicated that these tissues took up more phosphorus-32 than did normal controls[4]. The experimental procedures were quite different from those used here, and this may account for the differences in results.

With regard to sensitivity to X-rays and cortisone, the Friend leukæmia is like some chronic human leukæmias and lymphomas, whereas the transplanted mouse leukæmias in general are not[5]. With respect to phosphorus-32 uptake, as observed by us, the Friend leukæmia and the Gross virus-induced leukæmia resemble spontaneous mouse leukæmia and are different from the transplanted leukæmias we studied. It might be that the Friend leukæmia would be a valuable disease to use in screening programmes for drugs active against human leukæmia.

We are indebted to LeRoy Snellbaker and William Lane for technical assistance.

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Use of Glucose labelled with Carbon-14 to determine the Amino-Acids Essential for an Insect

A chemically defined diet is required for determining essential dietary components by the classical deletion procedure. It has proved difficult to rear plant-feeding insects on artificial diets[1,2]. A method that would permit the determination of essential factors such as amino-acids for insects not reared on chemically defined diets would be useful. In 1952, Steele[3] showed that carbon-14 appeared in the non-essential but not in the essential amino-acids when uniformly labelled sucrose-^{14}C was ingested by a mouse. This finding provides the basis for an indirect method of determining which amino-acids are essential in the diet. The present report compares results of the indirect method with those of the classical deletion procedure[4] for the blowfly *Phormia regina* Meig.

Third-instar larvæ of the blowfly from a laboratory stock colony were injected with 3–6 µl. of a solution of uniformly labelled glucose-^{14}C containing 5,000 counts/min./µl.

The larvæ were maintained on fresh liver in test-tubes placed in a desiccator equipped to permit collections of carbon dioxide in absorption flasks containing suitable solutions of potassium hydroxide and barium chloride. After 24 hr. the carbon dioxide was found to be radioactive. This showed that glucose-^{14}C, when injected into the larvæ, was metabolized during this stage of development.

After 68 hr., 24 insects were recovered from 50 injected larvæ, 13 had pupated, 6 were in the prepupal form, and 5 were still feeding. The insects were homogenized in a Potter–Elvehjem homogenizer first with hot 80 per cent ethanol and then with boiling water. The resulting residue was hydrolysed with 6 *M* hydrochloric acid for 24 hr. and the acid was removed *in vacuo*. The combined extracts were evaporated to dryness. Finally, the dry matters from the extracts and hydrolysate were extracted with water; the solutions were combined and placed on a column of 'Dowex-50' in the H-ion form. The amino-acids were fractionated on the column by first washing with water and then by gradient elution with hydrochloric acid to a final concentration of about 6 *M*[5]. The fractions containing a particular amino-acid, as indicated by paper chromatography and published elution curves[5], were combined, evaporated *in vacuo*, and further purified by band paper chromatography. After development of a band chromatogram the amino-acid was eluted with water, the eluate was concentrated, and chromatographed further. Four solvent systems were used in all cases: *n*-butanol/acetic acid/water (4 : 1 : 5); ethanol/ammonia (95 : 5); water-saturated phenol; and 95 per cent ethanol; further purification of individual amino-acids was made in other solvent systems when necessary.

Amino-acids eluted from final paper strips were dissolved in water and determined quantitatively by a general colorimetric method[6], or by more specific tests for proline[7], phenylalanine[8], arginine[9], histidine and tyrosine[10]. An aliquot of the amino-acid solution containing about 1 µ*M* of the compound was plated on a copper planchet and the radioactivity was determined with a gas-flow counter.

Table 1 shows that serine, glycine, glutamic acid, and aspartic acid, found non-essential by the deletion procedure, all contained the largest quantity of radioactivity. Leucine, threonine, valine, histidine, *iso*leucine, lysine, phenylalanine, and arginine, shown to be essential by the classical method, contained little if any radioactivity. Thus, these twelve amino-acids may be grouped as essential or non-essential according to their labels of radioactivity.

The presence of intermediate quantities of radioactivity in proline and alanine indicates that both were synthesized from glucose. Both would be considered non-essential by the present method, whereas proline was classed as essential by the deletion procedure. This discrepancy is being investigated.

The carbon of glucose was not involved in the synthesis of tyrosine by larvæ of the blowfly. This indicates that tyrosine is essential, but the deletion

Table 1. SPECIFIC ACTIVITIES OF CARBON FROM AMINO-ACIDS ISOLATED FROM THE BLOWFLY *P. regina* AFTER INJECTION WITH UNIFORMLY LABELLED GLUCOSE-^{14}C, AND AMINO-ACID REQUIREMENTS AS DETERMINED BY THE DELETION PROCEDURE

Amino-acid	Specific activity (c.p.m./µ*M* carbon)	Reported requirement (ref. 4)
Serine	22·6	–
Glycine	17·3	–
Glutamic acid	15·1	–
Aspartic acid	14·0	–
Proline	7·9	+
Alanine	3·5	–
Methionine	0·9	–
Leucine	0·6	+
Threonine	0·5	+
Cystine	0·3	–
Valine	0·3	+
Histidine	0·3	+
*iso*Leucine	0·3	+
Lysine	0·2	+
Tyrosine	0·1	–
Phenylalanine	0·0	+
Arginine	0·0	+

method showed that it was non-essential. The essential amino-acid phenylalanine is the principal precursor of tyrosine in the mouse[3] and the silkworm[11]. If this condition exists in the blowfly, then no radioactivity would be expected in tyrosine.

When the amino-acids were individually deleted from a defined diet neither methionine nor cystine appeared to be essential[4]. However, afterwards it was shown by the deletion of two or more amino-acids that *P. regina* required either methionine or cystine in the diet[12]. The low levels of radioactivity in the methionine and cystine isolated from the glucose-injected larvæ agree with the latter results.

The radioactivity method described here gave results for the blowfly *P. regina* that were sufficiently comparable to those of the classical deletion procedure to warrant application to insects that cannot yet be reared on chemically defined diets. There are some discrepancies between the two methods which will need further study. This technique, when applied to the different stages of insects, should provide a means for comparing synthetic abilities during development. Furthermore, the possibility of introducing labelled substrates into insects by other means, such as feeding and vacuum infiltration, will permit the method to be extended. A more complete description of this work along with similar studies using uniformly labelled glutamic acid will be published elsewhere.

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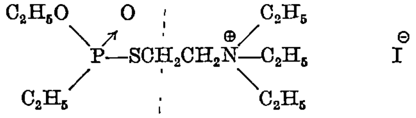
Role of Cholinesterase in Insecticidal Action

AMONG chemicals allied to the acaricide O,O′-diethyl-S-2-diethylaminoethyl phosphorothiolate, we examined the action of ethoxy ethylphosphinylthioethyl triethylammonium iodide (I) on the enzymes of the thoracic nerve cord of *Locusta migratoria migratorioides* R and F.



(I)

This substance, first prepared by Dr. R. Ghosh of this research station, is a moderate acaricide, being about half as toxic as parathion as a contact spray to *Tetranychus telarius* L. Against the locust it is of low toxicity, the *LD*50 being about 300–500 mgm./kgm. by injection. It is, however, a powerful *in vitro* inhibitor of the cholinesterase of the locust ganglion.

Metcalf *et al.*[1] have suggested that the lack of effect obtained by injection of cholinesters and prostigmine into insects[2,3] can be explained by the highly polar quaternary ammonium compounds being unable to penetrate the insect lipoid nerve sheath or synapses. On the other hand, the very closeness of the structure of this compound to acetylcholine suggests that it might well be broken down by enzymes occurring elsewhere than in the ganglion. Finally, the lack of correlation between toxicity to the locust and anticholinesterase activity of certain other non-polar organophosphorus esters[4] throws doubt on the importance of cholinesterase inhibition.

80–100 young virgin adult locusts were injected with 360–720 mgm./kgm. of (I) in buffered saline. Controls were injected with saline only. At intervals, the thoracic ganglia were dissected from a number of the injected locusts as follows: (1) 'Affected', prostrate, incapable of co-ordinated movement, no response to tarsal reflex, but not dead. (2) 'Unaffected', full co-ordination of movement and normal response to reflexes, indicating no interference with synaptic transmission, though, in the early stages, sometimes a little lethargic.

The dissected ganglia from affected, unaffected and controls were washed six times in ice-cold water, then ground in physiological saline (0·02 ml. per ganglion, ~ 0·02 ml./mgm.), diluted with 0·25 *M* sodium bicarbonate in physiological saline to give a concentration of 2 (in some cases 3) ganglia per Warburg flask. Cholinesterase activity was estimated by the usual Warburg method, involving the development of carbon dioxide from sodium bicarbonate with 0·002 *M* acetylcholine chloride as substrate. Activity measurements were taken over 1 hr. at 37° C.

With an inhibitor as powerful as (I) it is impossible to be certain of even the most meticulous washing method. A minute amount of the chemical left outside the ganglion would be intimately mixed with the enzyme during grinding and an inhibition be obtained *in vitro* which had, in fact, not occurred before dissection. To measure the amount of 'free' inhibitor, an equal amount of ground-up control ganglion homogenate was added to half the 'affected' and 'unaffected' flasks. If any unchanged (I) was present, it would exert its inhibitory power on the control homogenate as well as on the treated. On the other hand, if no free (I) was present, the activity of the mixture should be equal to that of a preparation containing an enzyme as active as the sum of the activities of the two constituent parts. This could be ascertained by the construction of standard curves, and in Table 2 'per cent inhibition' in the case of the mixtures refers to the expected values from these curves.

The validity of the method depends on knowing to what extent doubling the concentration of the enzyme affects inhibition at any one level. To establish this, a number of untreated locusts were dissected, and the

Table 1. PERCENTAGE *in vitro* INHIBITION FOR INCREASING ENZYME AND CONSTANT INHIBITOR CONCENTRATIONS

Concentration of inhibitor (*M*)	Ganglion equivalent in 2 ml.						
	2	3	4	5	6	7	8
1×10^{-9}	89	87	88	91	88	86	87
1×10^{-10}	82	81	79	71	62	65	59
1×10^{-11}	68		37		34		

Table 2. Course of *in vivo* Cholinesterase Inhibition

Experiment C55/34	Hours after injection							
	4		9		13		29	
	Acetylcholine decomposed (μmoles)	Inhibition (per cent)	Acetylcholine decomposed (μmoles)	Inhibition (per cent)	Acetylcholine decomposed (μmoles)	Inhibition (per cent)	Acetylcholine decomposed (μmoles)	Inhibition (per cent)
Affected	0	100	0	100	0	100	0	100
Affected + control	0	100	0·089	93	0	100	0·805	38
Unaffected	0	100	0	100	1·432	18	1·030	21
Unaffected + control	0·134	91	1·300	0	3·310	0	2·820	0
Control	1·478	—	1·255	—	1·748	—	1·300	—
Double control	3·850	—	3·810	—	3·265	—	4·080	—

ganglia homogenized in the usual way. Amounts of homogenate equivalent to 2–8 ganglia were then added to Warburg flasks containing a constant amount of inhibitor.

It appears that if the quantity of (I) is sufficient to inhibit the equivalent of 2 ganglia by about 90 per cent, quadrupling the amount of enzyme produces no significant change. Hence, if the ganglia of treated locusts show complete inhibition, and this was merely an *in vitro* effect produced subsequent to grinding, the addition of an equal amount of homogenate from untreated locusts should still give substantially complete inhibition of the mixture.

Other preliminary experiments have shown that when such an enzyme preparation is added to a solution of (I), the same amount of inhibition is obtained whether all the enzyme is added at once, or in two halves separated by 3 min. on ice. Finally, the slope of the *in vitro* inhibitor concentration/activity curve is such that the experimental dilution cannot affect the general picture. The above procedure would therefore appear to be reasonable.

Table 2 shows the result of a typical experiment. The dose injected was 360 mgm./kgm. and each figure is based on duplicate flasks.

The results of six experiments vary in detail, particularly on a time basis, but show essentially the same picture. While the inhibitor has great difficulty in penetrating the ganglionic sheath, some of it does reach the site of the enzyme and reacts with it. At the time of the first dissection there is an excess of the inhibitor present, resulting in inhibition of the mixtures as well as the affected and unaffected by themselves. At the time of the second dissection there is no further (I) left in the unaffected, the mixture of control and unaffected being as active as expected from the sum of control and unaffected. But all cholinesterase of the unaffected in this experiment and all or nearly all in other experiments appears to be inhibited, the enzyme showing no activity. After that, recovery takes place slowly. Even in the affected ganglia, detoxication seems to occur, as the mixtures in the later stages show some activity.

There is at least one other distinct enzyme, a phenylesterase, present in locust ganglia. (I) is a poor inhibitor of this, and in experiments of the type described its inhibition seems to be more correlated to toxic symptoms than that of cholinesterase. In the absence of information on its natural substrate or on the occurrence of other enzymes it is not possible to speculate on its role in the mode of action of phosphoric insecticides.

Unless synaptic transmission in the locust can be carried on normally by amounts of cholinesterase too small to detect by our method, it appears that a locust may have substantially all its ganglionic cholinesterase inhibited while showing no interference with normal nerve functioning. In that case it is hard to see what the role of this enzyme might be in the locust, or how its inhibition can be the cause of insecticidal action.

O'Brien[5] has shown that cockroaches poisoned by malathion show little *in vivo* reduction of cholinesterase activity, and similar results have been obtained by van Asperen[6] using O,O-dimethyl-O-2,2-dichlorovinyl phosphate on flies. Apparently there are cases when a toxic phosphorus ester produces little *in vivo* cholinesterase inhibition while killing, while others inhibit the enzyme very efficiently without killing.

It is hoped to publish a fuller account of experiments with this and other substances on more than one species in due course.

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Pigmentation and Sexuality in Plants

Many angiosperms depend on insects or birds to accomplish pollination or seed dispersal, and the appropriate parts of the plants are brightly coloured, usually with carotenoid or flavonoid pigments. It is generally agreed that these pigments serve a useful purpose in attracting animal visitors, and therefore their presence has selective value; but while this may explain their production and maintenance in some angiosperms, it does not account for their original establishment in the plant kingdom. For carotenoids similar to those commonly found in flowers and fruits occur in all lower groups of plants, and anthocyanins (flavonoids) are found both in mosses[1] and in ferns[2]. Hence there is reason for believing that both types of pigment were produced in plants long before angiosperms had evolved, and have some function or functions unconnected with attracting the attention of animals.

No attempt will be made here to give a comprehensive survey of the alternative functions which have been suggested; this communication is concerned only with the suggestion that there is a connexion between these pigments and the biochemistry of sex. There is considerable evidence for such a connexion with carotenoids, which occur regularly in all groups of plants. The evidence includes the differential accumulation of carotenoids in the sex organs of fungi[3], and of algae[4], and a correlation between carotenoid concentration and the reproductive cycle in flowering plants[5]. In addition, Moewus[6] claims to have demonstrated an elaborate system of hormones regulating the sexual process in the alga *Chlamydomonas eugametos*, in which carotenoids and their derivatives play an important part, but attempts to reproduce many of Moewus's results have been unsuccessful[7] and his claims should be treated with caution.

A connexion between sexuality and the flavonoid pigments, which occur only sporadically in the plant kingdom, is much less probable. Moewus[6] states that the anthocyanin peonin and the anthoxanthin *iso*rhamnetin are sex-determining hormones in *C. eugametos*; but this is unconfirmed and subject to the same criticism as above. Another piece of evidence comes from the observations of Gascoigne, Ritchie and White[8] on flower pigments in *Casuarina*. These authors identified the anthocyanidins from seven species of the genus, three of which showed no difference between male and female flowers in this respect. In each of the other four species, however, flowers of one sex yielded an anthocyanidin not present in flowers of the other, as shown in Table 1. Of these species, *C. glauca* is always diœcious, *C. nana* is usually diœcious, and *C. rigida* and *C. suberosa* may be either monœcious or diœcious.

Table 1. ANTHOCYANIDINS FROM FLOWERS OF *Casuarina* SPECIES (From Gascoigne, Ritchie and White, ref. 8)

Species	Anthocyanidins represented in:	
	Male flowers	Female flowers
C. glauca Sieb.	cyanidin	cyanidin + delphinidin
C. nana Sieb.	cyanidin	cyanidin + delphinidin
C. rigida Miq.	cyanidin	cyanidin + delphinidin
C. suberosa Ott. et Dietr.	cyanidin + peonidin	cyanidin

There is clearly no consistent difference of pigmentation between the sexes in the genus as a whole, and so it seems unlikely that the anthocyanins play a fundamental part in the biochemistry of sexual differentiation. Nevertheless, the differences observed in individual species seem to be more than coincidental. In particular, *C. glauca*, *C. nana*, and *C. rigida* all show the same difference between flowers of opposite sex, although *C. glauca* is not closely related to the other two species. It is possible that the difference in pigmentation represents a sex-limited character, that is, having only a secondary connexion with sex. For example, flowers of both sexes may have an enzyme which, under suitable conditions, can catalyse the conversion of cyanidin to delphinidin, but which can function only in the biochemical environment of female flowers.

A study of anthocyanin pigments in the flowers of other diœcious plants has been made on a small scale to see whether the sex difference in *Casuarina* has a parallel elsewhere. Flowers or inflorescences containing anthocyanins were collected from the six species listed in Table 2. Extracts of anthocyanins were made from male and female flowers separately and analysed by paper chromatography, both with and without previous hydrolysis, using techniques and solvents recommended by Bate-Smith[9,10]. For each of the six species, flowers from several male and several female plants in the same population were analysed in this way. In no case was there any evidence of a qualitative difference in anthocyanin pigmentation between flowers of opposite sex. The anthocyanidins were tentatively identified, and are given in Table 2.

Table 2. ANTHOCYANIDINS FROM MALE AND FEMALE FLOWERS OF DIŒCIOUS PLANTS

Species	Anthocyanidins
Melandrium rubrum	cyanidin
Myrica gale	cyanidin + delphinidin
Petasites hybridus	cyanidin
Rumex acetosella	cyanidin
Salix repens	cyanidin
Urtica dioica	pelargonidin

This negative finding strengthens the view that anthocyanins have no direct connexion with sexual differentiation, and that the differences reported for species of *Casuarina* are not representative of some more general phenomenon.

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Antibody Production by Single Cells

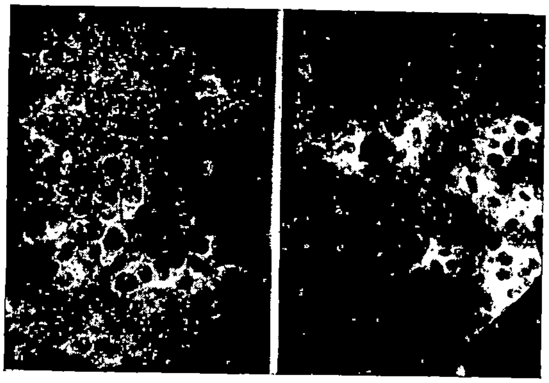
Nossal and Lederberg[1] described an ingenious and elegant method for showing that single cells from rat-lymph nodes, simultaneously stimulated with two antigens, formed antibody to one or other antigen but never to both.

This problem has been explored here by two further techniques which lead to the same general result as that given above, with different antigens and in a different animal species. The two methods employed the fluorescent antibody technique[2].

The first method used frozen sections of lymph nodes of rabbits simultaneously stimulated with two antigens (say *A* and *B*). The mature and immature plasma cells which contain anti-*A* were revealed by the 'sandwich' technique of Coons, Leduc and Connolly[3] using a dilute solution of a mixture of *A* and *B* and anti-*A* labelled with fluorescein. The distribution of fluorescent cells was photographed. The specific fluorescence of these cells was then quenched by exposure of the same microscopical field to long-wave ultra-violet radiation for 20–30 min. After this treatment a photograph confirmed the absence of specific fluorescence. Finally, after removal of the cover glass of the slide preparation, the cells containing anti-*B* were revealed by treatment of the section with fluorescein-labelled anti-*B*.

The second method used antibodies conjugated with red or green fluorochromes: sulphonyl chloride of rhodamine[4] or fluorescein *iso*cyanate. Frozen sections were treated with a dilute mixture of *A* and *B*, and then successively with anti-*A* labelled with fluorescein and anti-*B* labelled with rhodamine.

The first method has been applied to spleen sections from rabbits hyperimmunized by repeated intravenous injections of *Streptococcus pneumoniae* (type III) and crystalline hen's ovalbumin (tissue kindly supplied by Dr. J. H. Humphrey of the National



(a) (b)

Fig. 1. (a) Fluorescence micrograph. Medulla of rabbit spleen. Light areas (yellow-green fluorescence of fluorescein) indicate sites of antibody to capsular polysaccharide of *Str. pneumoniae* type III. Groups of antibody-containing cells (× 360). (b) Fluorescence micrograph. Same field as above, after quenching of specific fluorescence and after treatment to reveal distribution of anti-ovalbumin. Another set of cells distinct from those of (a) is revealed (× 360)

Institute for Medical Research) and to sections of popliteal lymph nodes of rabbits which were killed 3–6 days after a secondary stimulus of 50 *Lf* of diphtheria toxoid and 1 mgm. of ovalbumin adsorbed to aluminium phosphate, injected into a footpad. The animals had received simultaneous primary stimuli via the footpad with the same two antigens one month previously. The second method used the latter material only.

These treatments produced a heavy proliferation of plasma cells and their precursors in the pulp of the spleen or in the medulla of the popliteal node respectively. Comparison of the successive photographs provided by the first method, employing both combinations of antigens, showed that the two antibodies were located within distinct systems of plasma cell elements (Fig. 1, *a* and *b*). The use of the second method also resulted in two distinct sets of cells containing antibody, one with a yellow-green cellular fluorescence (of nuclei and cytoplasm) denoting anti-ovalbumin and one with the orange-red fluorescence denoting diphtheria antitoxin.

The use of the red and green fluorochromes would reasonably be expected to allow detection of two antibodies within a single cell providing that the amount of one is not grossly disproportionate to the other. The absence of such a result on a limited range of material does not prove that it cannot occur but implies at least that it is unusual.

On the basis of current hypotheses of clonal individuation in antibody formation[6,7] it might be expected that two groups of cells, which are derived by repeated divisions from widely dispersed precursors, would show a characteristic grouping. But although it was possible to discern a tendency for some cells of the same colour to occur in small clumps, marshalled clones of red and green were not apparent. This finding does not necessarily conflict with the hypothesis, providing the cells containing antibody are sufficiently motile in the medulla of spleen and lymph nodes. Evidence exists at least that they are motile[5]. Another type of lymphoid cellular proliferation which follows antigenic stimuli and which satisfies more fully the morphological requisites of clonal division is seen in the germinal centres of the lymphoid nodules. In certain circumstances these cells can be shown to contain antibody[8,9], and in my experience with animals producing both diphtheria antitoxin and anti-ovalbumin the cells of such a centre are nearly all of one kind (that is, either all green or all red by the above technique) and, thus far, appear to conform to the requirements of a clonal hypothesis.

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Effect of Calcium Ions on the Binding of Chromium-51 to Erythrocytes *in vitro*

SINCE Gray and Sterling[1] introduced the method of labelling erythrocytes with chromium-51 *in vitro*, numerous papers have appeared showing the usefulness of this method for determining the total red corpuscle mass and the life-span of the individual's own erythrocytes[2].

In spite of the widespread use of chromium-51 as a labelling agent for the erythrocytes, relatively little is known about the basic mechanism of chromate binding to the erythrocytes. It has been shown repeatedly that the percentage uptake of chromium-51 by red corpuscles is higher using isotonic sodium citrate (ACD) solution as an anticoagulant than when heparin is used[3].

We wish to report that the presence of calcium ions in the incubation medium diminishes the uptake of chromium-51, added as sodium chromate, by erythrocytes and hæmoglobin *in vitro*.

Fresh human blood was drawn into different anticoagulants. The preparation of globin and hæmoglobin solutions will be described elsewhere by one of us (B. Z.). Labelled sodium chromate ($Na_2{}^{51}CrO_4$) with a specific activity of 5 μc./μgm. of metallic chromium was employed. 0·3 μc. of chromium-51 was added to 5 ml. of whole blood. The blood was incubated at 20° C. for 2 hr. After centrifuging, the red corpuscles were washed four times with physiological saline and, after hæmolysis, their radioactivity was compared to that of a standard sample.

Using heparin as an anticoagulant, the uptake of chromium-51 by the erythrocytes is reduced to two-thirds of the uptake in isotonic sodium citrate or oxalate solutions.

Table 1 shows that the calcium ions reduce the amount of chromium-51 taken up by erythrocytes suspended in saline or in recalcified sodium citrate plasma from about 90 per cent to about 60 per cent of the added chromate. The binding of chromium-51 to human globin or hæmoglobin *in vitro* is similarly decreased in the presence of calcium ions (unpublished work by B. Z.). This fact suggests that the effect of calcium ions on the uptake of chromate by red corpuscles is probably not due to a change in membrane permeability of the erythrocytes. Further

Table 1. THE EFFECT OF CALCIUM IONS ON THE UPTAKE OF CHROMIUM-51 BY HUMAN ERYTHROCYTES *in vitro*

Incubation medium	Percentage of uptake
ACD-solution* whole blood = 1/4	90
ACD-solution* whole blood = 1/4 + Heparin	89
ACD-solution* whole blood = 1/4 + Heparin + 2 mgm. Ca^{2+}/ml.	58
Saline Packed RBC = 2/1	91
Saline Packed RBC = 2/1 + 0·1 mgm. Ca^{2+}/ml.	63

* Natr. citr. tribas., 1·32 ; acid. citr., 0·48 ; glycos., 1·47 ; aqua dest., ad 100 ml.

studies on the mechanism of the inhibition of chromate-binding to erythrocytes or hæmoglobin by calcium ions, and on the influence of calcium ions on the elution of chromium-51 from the erythrocytes, are in progress in this laboratory.

Our grateful thanks are due to Prof. G. de Hevesy for stimulating interest taken in this investigation ; to Statens Naturvetenskapliga Forskningsrad ; and to Riksföreningen för Kräftsjukdomarnas Bekämpande, Cancernämnden, for financial support.

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Volume and Acidity of Urine of Sheep fed Hay Rich in Silica and Effect of Dietary Salt Additions

THE results reported in this communication were obtained as part of a study related to a condition of silica urolithiasis which had been observed in steers on the Western Ranges[1] of Canada and the United States. Experiments in this laboratory have shown that sheep fed a hay from Western Canada containing 8·28 per cent silica (expressed on air-dry basis) excreted urine with a *p*H of approximately 5·5. Sheep in the control group that were fed a hay from Eastern Canada containing 0·78 per cent silica excreted urine with a *p*H of approximately 8·2. Consumption of water and excretion of urine by sheep fed the high-silica hay were about one-half that of the sheep in the control group.

The polymerization of silicic acid in aqueous systems is dependent on concentration and *p*H. Rate of polymerization is stated to be inversely proportional to the square of the silica concentration[2] and most rapid at *p*H 5·5–6 (ref. 3), 5·8 (ref. 4), 5–7 (ref. 5). It is therefore possible that the effects on volume and *p*H of urine that resulted from the feeding of Western grass hay may play a part in the formation of silica calculi.

The proximate composition and cation content of the two hays is given in Tables 1 and 2. The Western hay was mainly *Stipa*, probably *Stipa comata*, whereas that from Eastern Canada consisted of second cut red clover (*Trifolium pratense*). In the experiment reported here two groups of three sheep were used. One group was fed the Eastern and the other the Western hay, with salts added in order to render the cation content of the two diets approximately equal. Each sheep on Western hay received daily the following additions based on an average daily hay consumption of 1,000 gm. : sodium hydrogen phosphate, 2·4 gm. ; magnesium carbonate, 3·3 gm. ; magnesium sulphate, 4·7 gm. ; calcium carbonate, 15·0 gm. ; potassium bicarbonate, 15·6 gm. ; potassium chloride, 6·5 gm. Sheep fed the Eastern hay were given a daily addition of 112·5 gm. silica in the form of a commercial silica gel based on an average daily consumption of hay of 1,500 gm. Four samples of urine were collected daily over a 4-week period and the *p*H values determined on the fresh urine. 24-hr. urine volumes were determined three times a week.

Table 1. PROXIMATE PERCENTAGE ANALYSES OF EASTERN AND WESTERN HAYS

	Protein N × 6·25	Fat	Crude fibre	Ash	N-free extract
Eastern hay	11·74	1·46	31·32	6·72	48·76
Western hay	5·87	1·89	32·63	13·06	46·55

Table 2. MINERAL ANALYSES OF EASTERN AND WESTERN HAYS

	Na	K	Ca	Mg	P	SiO_2
Eastern hay	0·06	1·35	0·92	0·27	0·15	0·78
Western hay	0·02	0·44	0·32	0·08	0·12	8·28

Addition of silica to the diet had very little effect on either the volume or the *p*H of the urine. On the other hand, addition of salts to the diet of sheep fed the Western hay resulted in a urine volume comparable to that of the control group. In addition there was some elevation in urine *p*H but this was subject to considerable fluctuation. In order to overcome this fluctuation in *p*H, equivalent amounts of magnesium and potassium as magnesium carbonate and potassium bicarbonate were used to replace the magnesium sulphate and potassium chloride. This resulted in *p*H values of approximately 8·0. No ill effects attributable to the administration of salt were observed during the experiment.

Our studies on urolithiasis so far have suggested that low *p*H and low excretion of urine may be important factors contributing to the formation of silica calculi. If this is correct, proper additions of salts to the diet may contribute to the reduction of silica urolithiasis.

A more detailed account of these experiments will be published in the near future.

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Vitamin B_{12} in Marine Fish

IN the course of a comparative investigation of the vitamin contents of different organs from fish[1], a rather interesting relative distribution, and in some cases unusually high concentrations, of vitamin B_{12} were observed. As the importance of vitamin B_{12} in marine ecology has been emphasized in recent reports[2-6], a brief account of the main findings is given in this communication.

Vitamin B_{12} was determined by microbiological assays with *Lactobacillus leichmannii*. To ensure that the growth-promoting activity measured was derived from vitamin B_{12}, checks were carried out by paper chromatography.

Although most organs have been investigated the complete results cannot be reported here. In Table 1 are shown the results of analyses of: muscle, kidney, liver and heart from some species. The most striking results are the frequent high values for vitamin B_{12} in the heart: single values up to 5 μgm. vitamin B_{12} per gm. fresh weight (20·8 μgm. per gm. dry weight) were found in hearts from the pollack (*Gadus pollachius*). So far as we know such high concentrations are very unusual in any natural source[8]. Another interesting result was the relation between the vitamin B_{12} content of liver and heart. In some cases the heart showed up to 150 times the value for the liver in the same fish. Normally, kidney and liver are recognized as the organs richest in vitamin B_{12}[7], but the present findings show that in fish the heart often contains the highest concentration. Tarr *et al.*[8] found in the kidney of the sockeye-salmon 18 μgm. vitamin B_{12} per gm. solids. Several other organs from this fish were also investigated, but unfortunately not the heart. In none of the species I investigated were such values for kidneys encountered.

Table 1. THE VITAMIN B_{12} CONTENT OF SOME ORGANS FROM FISHES

Species	μgm. vitamin B_{12} per gm. fresh weight			
	Muscle	Kidneys	Liver	Heart
Cod (*Gadus morrhua*)	0·005	0·045	0·045	1·85
Coalfish (*Gadus virens*)	0·035	0·070	0·14	0·50
Pollack (*Gadus pollachius*)	0·018	0·16	0·33	4·25
Haddock (*Gadus aeglefinus*)	0·018	0·32	0·067	2·58
Ling (*Molva molva*)	0·006	0·20	0·11	0·26
Tunny (*Thunnus thynnus*)	0·037	0·35	3·53	0·85
Plaice (*Pleuronectes platessa*)	0·022	0·37	5·00	0·81

So far the general picture seems to be that undernourished fish with very fat livers show low values for vitamin B_{12} in the livers and often very high values for the heart. Fat fish with 'normal' livers usually show the highest values for this organ, although high concentrations are also encountered in the hearts.

The results from the plaice (*Pleuronectes platessa*) deserve some comments. This fish lives in shallow waters where both the sea and most of its food may be expected to contain relatively high concentrations of vitamin B_{12}. It is therefore interesting to note the relatively high average value for the liver from this fish. Actually, in one of the samples from plaice the liver contained 8 μgm. vitamin B_{12} per gm. fresh weight (50 μgm. per gm. fat-free dry weight).

The results emphasize the position of the fish in the turnover of vitamin B_{12} in marine life. A detailed account of this work will be published elsewhere.

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Deoxyribonuclease Activity and Deoxyribonucleic Acid Synthesis in Normal, Regenerating, Precancerous and Cancerous Rat Liver

INCREASE in the rate of deoxyribonucleic acid synthesis is a biochemical characteristic of hyperplastic growth. Whereas the rate of growth under normal conditions is under rigorous control, malignant growth may be characterized by the impairment of this kind of control. Since deoxyribonucleic acid synthesis is necessary for cell division, it is possible that this control may be exercised by the regulation of deoxyribonucleic acid metabolism. The purpose of this communication is to direct attention to a number of observations which, taken together, seem to indicate that deoxyribonuclease may be involved in such regulation.

In previous experiments[1,2] a close correlation between the activity of a deoxyribonuclease with *p*H optimum close to 5 and growth-rate or rate of synthesis of deoxyribonucleic acid has been demonstrated in normal tissues; increase in growth-rate was in all cases studied associated with increase in the level of deoxyribonuclease activity per cell. In contrast to this pattern in normal tissues, a lack of correlation between growth-rate and deoxyribonuclease activity was found in a series of malignant human and animal tissues[3]. The deoxyribonuclease activities of the tumours were approximately equal to, or lower than, those found in the tissues of origin.

In the search for an explanation of these apparent differences between normal and malignant growth, a systematic study has been made of the deoxyribonuclease activity in rat liver in various types of normal and malignant growth. Such a study makes possible a comparison of these various conditions in a single organ. Male Sprague–Dawley rats, weighing 250–300 gm., were used. The enzymic activities were determined in normal adult liver, in regenerating liver after partial hepatectomy, and in precancerous and cancerous livers, where the tumour was induced by feeding a rice diet containing 0·06 per cent *p*-dimethylaminoazobenzene[4] and supplemented with carrots. After three months, casein was added to the diet. The deoxyribonucleic acid phosphorus content and deoxyribonuclease activities were determined as described previously[5].

Table 1 is a summary of some of the results. Compensatory hyperplasia after partial hepatectomy is accompanied by an increase in deoxyribonuclease activity; the increase is very rapid and is observed

Table 1. Deoxyribonuclease Activity and Deoxyribonucleic Acid Phosphorus Content in Normal, Regenerating, Precancerous and Cancerous Rat Liver

Experimental procedure	Characterization of tissue	No. of animals	Wet weight of livers (gm.)	μgm. DNAP* per gm. dry weight	mgm. DNAP* per total organ	DNase† per μgm. DNAP*	DNase† per total ogan
Normal controls		6	11·83	710	2·35	9·4	22,000
Sham operation	24 hr. after op.	2	—	705	—	10·5	—
Partial hepatectomy	12 hr. after op.	3	4·29	642	0·77	12·3	9,470
	24 ,, ,, ,,	15	4·83	550	0·77	16·4	12,600
	36 ,, ,, ,,	8	6·44	580	1·09	15·0	19,400
	41 ,, ,, ,,	4	6·67	670	1·16	18·0	20,880
	48 ,, ,, ,,	4	7·87	740	1·70	17·1	29,000
	72 ,, ,, ,,	8	8·65	750	1·98	16·1	31,880
p-Dimethylaminoazobenzene fed	4 days	4	11·60	692	2·34	10·3	24,310
	8 ,,	4	11·36	835	2·83	9·6	27,460
	14 ,,	4	12·24	826	3·04	15·2	46,200
	60 ,,	4	11·96	1,210	4·45	15·3	68,540
	90 ,,	3	12·99	950	3·33	12·9	47,700
	150 ,, ‡	1	—	1,040	—	11·7	—
	150 ,, §	1	—	3,140	—	5·7	—

* DNAP, deoxyribonucleic acid phosphorus.

† DNase (deoxyribonuclease) activities were determined by incubating tissue homogenates with calf thymus deoxyribonucleic acid at *p*H 5·25, adding trichloracetic acid – lanthanum acetate and centrifuging. The increase in deoxypentose in the supernatant was determined colorimetrically (ref. 5) and from this the amount of deoxyribonucleic acid phosphorus was calculated. The deoxyribonuclease activities are expressed as μgm. deoxyribonucleic acid phosphorus liberated per hr. per μgm. tissue deoxyribonucleic acid phosphorus or per total organ.

‡ Diffuse tumour infiltration.

§ Excised solid hepatoma.

as early as 12 hr. after operation. A high level of deoxyribonuclease is also found in rats on the *p*-dimethylaminoazobenzene diet. It is observed after 14 days, and approximately the same level is found at 60 days. After 90 days the value gradually decreases. The lowest values are found in the hepatoma. The deoxyribonuclease activity of this tissue is considerably lower than that of normal adult liver.

The growth response to partial hepatectomy in terms of deoxyribonuclease increase is very rapid. At 36 hr. after the operation, the remaining fragment of liver has a total deoxyribonuclease activity approximately equal to that of the intact organ, whereas during the same time interval only a fraction of new deoxyribonucleic acid has been synthesized (Table 1). The figures indicate that the peak-rate of deoxyribonucleic acid synthesis occurs somewhere between 39 and 44 hr. after partial hepatectomy. The prolonged stimulation of growth exerted by *p*-dimethylaminoazobenzene is associated with higher levels of deoxyribonuclease during the early stages of the carcinogenic process. The induced hepatoma, however, appears to have lost the capacity to respond to the continuous growth stimulation with an increase in deoxyribonuclease activity.

These findings seem to be in harmony with the protein deletion hypothesis put forward by Miller and Miller[6]. During precancerous stages, there is an accumulation of protein-bound derivatives of the azo dye in the rat liver. This seems to cause hyperplasia, which is accompanied by increase in cellular deoxyribonuclease activity. This increase appears to be a general reaction of the normal cell to a growth stimulus[1,2]. Gradually, however, a new type of cell, the cancer cell, appears, lacking, *inter alia*, the protein fractions which in the normal rat liver cell are bound to derivatives of the dye[6]. It is conceivable that some of these protein fractions might be concerned with deoxyribonuclease synthesis.

In summary, it can be said that in the rat liver during non-malignant growth increased rate of deoxyribonucleic acid synthesis is accompanied by increased deoxyribonuclease activity. The malignant cell is characterized by considerably increased rate of deoxyribonucleic acid synthesis[7] and subnormal deoxyribonuclease activity. During the carcinogenic process induced by *p*-dimethylaminoazobenzene, the early stages are associated with increased deoxyribonuclease activity, which decreases during the later phases of this process.

A detailed report on these findings and parallel histological changes will be published elsewhere.

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Importance of Zinc for the Growth of Surface-Culture of *Mycobacterium tuberculosis* var. *bovis* and Large-scale Production of Tuberculin Purified Protein Derivative

DURING the past eight years of large-scale cultivation of *Myc. tuberculosis* var. *bovis* '*AN*5' on the Dorset–Henley synthetic liquid medium[1,2] for the production of tuberculin purified protein derivative, from time to time and especially during the past two years we have met serious difficulties due to premature sinking of the pellicles, about 3–6 weeks after inoculation (the normal time before harvesting being 8 weeks). Growth came to a standstill and losses in tuberculin production were substantial.

We checked several crucial points in the procedure, including the possibility that toxic products, for example peroxide, developed during autoclaving. We also introduced some improvements. By placing the penicillin flasks, in which the pellicles are grown, on a slant instead of horizontally, condensed moisture was prevented from dripping down. In this way the piercing of holes in the pellicles by water drops was avoided. By introducing in the inoculation scheme more natural media, such as Stonebrink's egg–pyruvic acid medium and Sauton's potato medium, we got better seed material. Nevertheless, the main cause of sinking still remained undetected and we turned our attention to trace elements, which had previously been neglected in checking the medium constituents.

L. A. Baisden[3] recommended the addition of many elements to the Dorset–Henley medium, which is composed of: L-asparagine, dipotassium hydrogen phosphate, trisodium citrate, magnesium sulphate, ferricitrate, glucose and glycerine. This was mainly because many brands of asparagine do not contain the impurities necessary for good growth of *Mycobacterium* cultures. Drea and Andrejev[4] pointed out some essential elements but they considered several others, including zinc and manganese, unessential.

A striking result of the investigations of Williston *et al.*[5] on the reasons for the premature sinking of some of their BCG cultures on Sauton media was the detection of the favourable effects of traces of zinc, present in some of their glycerine batches due to corrosion of galvanized containers. Similar results were obtained by Loginova[7].

Williston *et al.*[5] recommended the addition of both zinc and manganese, even if traces of these elements were present in the other constituents of the medium. We therefore investigated the effects of zinc on our bovine *AN*5 strain on the Dorset–Henley medium.

Zinc estimations, carried out since April 1958 on our glycerine batches and on complete culture medium revealed that less than 2 μgm./ml. was present. Manganese, often encountered in natural asparagine and probably in ferricitrate, was present, at concentrations of about 1–3 μgm./ml. medium.

We therefore added to our media: 10 μgm. zinc/ml. (60 flasks); 10 μgm. zinc + 2·5 μgm. manganese/ml. (5 flasks); 10 μgm. zinc + 2·5 μgm. manganese + 0·35 μgm. cobalt/ml. (5 flasks). The elements were added as A.R. sulphate, chloride and chloride respectively. Five flasks with non-enriched media served as controls.

We used cobalt (Williston *et al.*[5] were doubtful about its effect on growth) to neutralize peroxide which might be formed by autoclaving Mn^{++} and citrate[6]. Sinking occurred in the controls after about 3 weeks, while the other inoculates grew satisfactorily. The pellicles grown on the three kinds of enriched media appeared normal at the time of harvesting, and were indistinguishable by eye from each other. Similarly, the addition of more zinc (20 μgm. zinc + 2 μgm. manganese + 0·35 μgm. cobalt) gave excellent results.

It must be pointed out that pellicles of the human strains *DT*, *C* and *PN* were slightly less apt to sink than those of the bovine strain. Human strain pellicles did not sink on the zinc-deficient media on which bovine pellicles did, though the growth was not so good as on media to which zinc had been added.

The yields of tuberculin from all the enriched batches were about 1·5–2 times those from sinking cultures, and equal to, or perhaps slightly better than, from our former successful cultures in which trace-elements were not investigated.

The colour of the protein precipitate from media enriched with zinc is strikingly whiter than that from sinking cultures. This led us to suppose that possibly the proportion of the almost white '$A + B$' proteins, known for their greater specificity in the intradermal test[8], might be higher in the former case.

Tested on guinea pigs sensitized with mammalian tuberculosis, the potency of the 'zinc-added' tuberculin (15 *TU* per injection) proved to be significantly higher than that of tuberculin from sinking cultures. The average swelling diameters were respectively 13·5 and 11·1 mm. On the other hand, the reactions provoked by 1,500 *TU* on avian-sensitized guinea pigs were similar for both products. Higher specificity is thus indicated as well.

Confirmation of this was provided by chromatography[9]: the percentage of '$A + B$' protein in 'zinc-added' tuberculoprotein was about 2–3 times that in tuberculoprotein from sinking cultures.

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Immunology and Chromatography in Taxonomic Studies on Gallinaceous Birds

I HAVE recently described a correlation between antigenic properties and hæmoglobin composition of the blood of some passerine birds[1]. The relationships of red-cell antigens and of hæmoglobins suggested some possible phylogenetic affinities among these birds, since these characters are gene-determined. There was very little intraspecific variability.

An immunological analysis of red-cell antigens and a chromatographic analysis of pectoral muscle of three species of gallinaceous birds have been made. The three species, *Numida meleagris*, *Gallus gallus* and *Meleagris gallopavo*, belong, according to Wetmore's classification[2], to three different families of the order Galliformes, sub-order Galli, superfamily Phasianoidea.

The genetic properties of red-cell antigens and the inferences that can be drawn from immunological relationships on phylogeny and systematics have been largely discussed[3]. Also the application of paper partition chromatography has proved useful for understanding phylogenetic relationships. Buzzati-Traverso and Rechnitzer[4], Buzzati-Traverso[5], Micks[6] and Fox[7] have shown that chromatographic patterns of different species show constant differences, independently of environmental conditions, and that their similarities run parallel to their phylogenetic affinities.

The anti-erythrocytes sera of the three species of birds have been obtained from rabbits; the specific antigens have been separated from the common ones by absorption, and titrations have been made in serial dilutions at 37° C. The titres are given in Table 1. Every species possesses: (1) specific antigens; (2) antigens common to the other two species; (3) antigens common only to one of the other two. There is greater immunological affinity, that is, more common antigens, between *Meleagris gallopavo* and

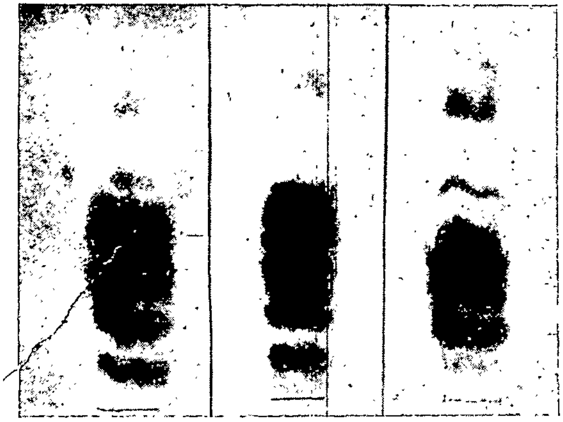
Table 1

Antiserum	Absorbing cells	Test cells		
		Gallus	*Numida*	*Meleagris*
Gallus	—	1/1,280	1/80	1/40
	Numida	1/640	—	1/20
	Meleagris	1/640	1/20	—
Numida	—	1/40	1/5,120	1/320
	Gallus	—	1/640	1/160
	Meleagris	1/20	1/40	—
Meleagris	—	1/80	1/1,280	1/1,280
	Gallus	—	1/640	1/320
	Numida	1/10	—	1/320

Numida meleagris than between these two species and *Gallus gallus*.

For ascending paper partition chromatography the following technique has been used. Pectoral muscle is homogenized in a tissue grinder with distilled water (1 muscle : 2 distilled water); then, after centrifugation, the supernatant is deproteinized by 20 per cent trichloracetic acid, and the excess of the latter is removed by ether. The liquid is concentrated (1/3) by evaporation at 2° C. Whatman No. 1 filter paper is used. The solvent consists of 1 part of 1 per cent ammonia and 2 parts of *n*-propanol. The chromatograms are sprayed with a 0·2 per cent solution of ninhydrin in 95° ethanol.

Chromatographic patterns of pectoral muscle of several individuals of the same species were identical.



Numida *Meleagris* *Gallus*

Fig. 1

As can be seen in Fig. 1, there is greater similarity between the chromatograms of *Numida meleagris* and *Meleagris gallopavo* than between these two species and *Gallus gallus*. Consequently, this chromatographic similarity confirms the closer immunological affinity between *Numida* and *Meleagris*.

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The Heterozygous Carrier in Galactosæmia

GALACTOSÆMIA is a hereditary disorder of carbohydrate metabolism characterized by vomiting, diarrhœa, jaundice, poor weight gain and malnutrition during early infancy. Mental retardation, cataracts and cirrhosis of the liver are common complications. The diagnosis can be made by a markedly elevated galactose tolerance test, and identification of galactose in the urine. In 1956, Schwarz, Goldberg, Komrower and Holzel[1] showed that galactose-1-phosphate accumulates in the erythrocytes of galactosæmic children if they receive galactose or milk. This indicated that galactokinase must be present in such individuals. In the same year, Isselbacher, Anderson, Kurahashi and Kalckar[2] demonstrated a deficiency of galactose-1-phosphate-uridyl transferase in the erythrocytes of these children. This indicated that the site of the metabolic block in this disease was at the step of:

$$\text{Galactose-1-PO}_4 + \text{UDP glucose} \rightleftharpoons \text{UDP galactose} + \text{glucose-1-PO}_4$$

The frequent occurrence of this condition in siblings and among the offspring of consanguineous matings together with its equal distribution in both sexes suggest that galactosæmia is probably transmitted by a single autosomal recessive gene. In this situation, one would expect the disease to occur only in persons who receive two of the abnormal genes, one from each parent. If one individual is heterozygous for the condition, he will usually be free of clinical symptoms. Careful biochemical studies, however, might reveal minor departures from the norm[3]. Holzel and Komrower[4] undertook galactose-tolerance tests among parents, siblings, and near relatives of six families with known cases of galactosæmia. They found the response to be abnormal in a number of the relatives tested, but this was not a consistent finding among all the individuals who should be heterozygous. Furthermore, in the majority of cases, usually only one of the parents showed a lowering of the galactose-tolerance test.

The purpose of the present communication is to report on the measurement of galactose-1-phosphate-uridyl transferase activity in five galactosæmic families. In each instance, the diagnosis of galactosæmia was established by identifying the presence of galactose in the urine through paper chromatographic separation or by the osazone and mucic acid test or both. Galactose-1-phosphate-uridyl transferase activity was assayed by the method of Anderson, Kalckar, Kurahashi and Isselbacher[5], as follows. Red blood cells of fasting venous blood were washed twice with a double volume (twice the volume of the packed cells) of 0·9 per cent sodium chloride and hæmolysed by the addition of an equal volume of cold distilled water. Hæmolysate was then incubated with uridine diphosphoglucose (UDPG), galactose-1-phosphate, and *tris* glycine buffer for 30 min. at 37° C. For each sample, a control was run where no galactose-1-phosphate was added to the substrate. After incubation, diphosphoglucose was determined in heat-inactivated hæmolysates by means of diphosphoglucose dehydrogenase. The difference between the measurements of diphosphoglucose in the sample and control represents the amount of it consumed due to the activity of galactose-1-phosphate-uridyl transferase. Uridine diphosphoglucose pyrophosphorylase activity was

Table 1. GALACTOSE-1-PHOSPHATE-URIDYL TRANSFERASE ACTIVITY (EXPRESSED AS UNITS/GM. HÆMOGLOBIN) IN SIX GALACTOSÆMIC FAMILIES

(*a*) Families where parents are heterozygotes				
Family	Parents		Children	
	Father	Mother	Affected	Unaffected
1	3·2	2·6	0·31 ; 0	—
2	3·8	5·4	0	3·2
3	5·5	4·5	0 ; 1·1	—
4	2·5	1·9	3·6*	—
5	1·8	1·7	0·6 ; 1·0	1·8 ; 2·5
(*b*) Family where offspring are heterozygotes				
	Father		Offspring	
6	0·9		1·7 ; 2·1 ; 4·1	

* Sample taken from 3-kgm. infant after receiving 195 ml. of whole blood.

Table 2. SUMMARY OF GALACTOSE-1-PHOSPHATE-URIDYL TRANSFERASE ACTIVITIES OF NORMALS, HETEROZYGOTES AND AFFECTED

	Galactose-1-phosphate-uridyl transferase activity (unit/gm. hæmoglobin)		
	Normal controls	Heterozygotes	Affected
No. of subjects	11	12	8
Mean	4·5	3·3	0·5
S.D.	± 1·5	± 1·2	± 0·12
Range	2·8–7·0	1·7–5·5	0–1·07

also determined to assure that the blood sample and the hæmolysate were properly handled.

Results for eleven normal controls, twelve heterozygotes (nine were parents, two were offspring, and one was both a parent and an offspring of patients with galactosæmia) and nine galactosæmics are tabulated in Table 1 and summarized in Table 2. It would appear that about half the levels of galactose-1-phosphate-uridyl transferase among the heterozygotes lie below the range of the normal controls, and the difference between the means is significant at the 0·05 level.

All the blood samples were taken in a fasting state. A dose of 40 gm. of D-galactose was given by mouth to four of the heterozygotes and 1·25 gm./kgm. body-weight to two of the affected children. In Table 3 are listed the galactose and galactose-1-phosphate-uridyl transferase levels in whole blood and the erythrocytes respectively before, 1 hr. and 2 hr. after this load. There appears to be a decrease in the galactose-1-phosphate-uridyl transferase activity following the load in both of the affected children and in two of the four heterozygotes. The possible significance of these findings is being further evaluated.

While the results in a single individual must be interpreted with caution, the lower values of galactose-1-phosphate-uridyl transferase found in a group of heterozygotes offer confirmation for the view that the lack of this enzyme is the primary biochemical lesion in galactosæmia. Furthermore, the decrease of this enzyme in the heterozygote with one abnorm gene and its virtual absence in the homozygote wit two abnormal genes extend the possibility of detec ing heterozygous carriers biochemically, as in t case of abnormal hæmoglobins[6], phenylketonuri and glycogen storage disease of the liver (Hsi D. Y. Y., and Gawronska, E., unpublished work).

Table 3. BLOOD GALACTOSE LEVEL AND GALACTOSE-1-PHOSPHATE-URIDYL TRANSFERASE ACTIVITY FOLLOWING THE ADMINISTRATION OF 40 GM. OF D-GALACTOSE TO FOUR HETEROZYGOTES, AND 1·25 GM./KGM. BODY-WEIGHT TO TWO GALACTOSÆMIC CHILDREN

Time (hr.)	Galactose (mgm. per cent)			Galactose-1-phosphate-uridyl transferase (units/gm./kgm.)		
	0	1	2	0	1	2
Affected	7	86	54	0·6	0·5	0·3
Affected	10	45	10	1·0	0·8	0·5
Heterozygote	7	31	10	1·8	1·0	0·9
Heterozygote	8	28	6	1·7	1·8	1·7
Heterozygote	4	53	8	3·2	2·5	1·8
Heterozygote	5	43	40	2·5	2·9	2·2

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Fomes noxius, a Thiamine-deficient Fungus

THE tropical brown root disease, caused by *Fome noxius* Corner[1], is of widespread occurrence and i found on the roots of a great number of tropica plants such as *Artocarpus*, *Cinchona*, *Cacao*, *Coffea* *Grevillea*, *Erythrina*, *Eriodendron*, *Elaeïs*, *Hevea* *Thea*, *Theobroma* and of forest trees.

The correct scientific designation of the fungus i not quite clear, and various authors have recorded i under different names : for example, Petch[2] refers t it as *Fomes lamaensis* (Murr.) Sacc. ex Trott., whil Roger[3] describes it as *Phellinus lamaensis* (Murr. Sacc. ex Trott. In this communication Corner' designation is followed.

The distinguishing characteristic of the brown roo disease is the fine brown fungus mycelium whic covers the roots of affected plants like a sheath ; soi particles and small stones adhere to this brow mycelium cover. The fungus later forms a thic brown or blackish felted crust on the affected root The outer layer of the crust is brittle and blackish i appearance but the mycelium of the inner laye remains mostly brown. Under this crust the disease bark disintegrates and the wood is penetrated by network of branching brownish-black lines or b bands of the mycelium.

So far as can be ascertained from available litera ture[4], *Fomes noxius* has not yet been grown o investigated in pure culture.

As *Fomes noxius* belongs to the group of th Hymenomycetes which is known to be partially o totally deficient in thiamine (aneurin, vitamin B_1) the requirements of this fungus in this particula respect have been investigated.

Attempts to grow *Fomes noxius* in purely artificial media, as those of Czapek, Fries, Richard or Knop, were unsuccessful. However, as soon as organic materials, such as malt extract, yeast extract, decoc-ion of wood of *Hevea brasiliensis* or of fresh *Hevea* eaves were added, luxuriant growth of the fungus was observed. The fungus also grows well on sterilized pieces of fresh rubber wood and of the roots of rubber, tea or cocoa plants.

Our experiments were carried out in 500-ml. Jena Erlenmeyer flasks, each series consisting of ten asks. All experiments were replicated three times, nd the chemicals used were of analytical grade.

In order to obtain a uniform inoculum for these xperiments, the fungus was pre-cultivated for 42 ays on sterilized pieces of fresh rubber wood. The mycelium suspension was prepared by adding 100 ml. of sterile distilled water to each flask followed by igorous shaking. The Erlenmeyer flasks containing the culture media were then inoculated by the wet method, each flask with 0·5 ml. of the mycelium suspension, and the cultures then incubated for 28 days t 27° C.

Knop solution containing 10 gm./l. of vitamin-free lucose was used as basic medium for these experiments.

able 1. *p*H AND MYCELIUM DRY WEIGHTS IN MGM. OF *Fomes noxius* N KNOP-GLUCOSE MEDIUM WITH AND WITHOUT ASPARAGINE, HIAMINE, THIAZOLE OR PYRIMIDINE AFTER 28 DAYS AT 27° C.

Culture medium, Knop +	*p*H of culture medium at beginning	at end	Mycelium per flask (dry weight in mgm.)
10 gm./l. glucose	5·0	4·7	1·8
10 gm./l. glucose 1 gm./l. asparagine	5·0	3·5	3·3
10 gm./l. glucose 0·5 mgm./l. pyrimidine	5·2	5·1	2·4
10 gm./l. glucose 0·5 mgm./l. thiazole	5·2	4·6	3·0
10 gm./l. glucose 1 gm./l. asparagine 0·5 mgm./l. pyrimidine	5·2	3·3	10·4
10 gm./l. glucose 1 gm./l. asparagine 0·5 mgm./l. thiazole	5·3	3·8	12·2
10 gm./l. glucose 0·5 mgm./l. pyrimidine 0·5 mgm./l. thiazole	5·0	4·8	2·7
10 gm./l. glucose 1 gm./l. asparagine 0·5 mgm./l. pyrimidine 0·5 mgm./l. thiazole	5·3	4·8	288·6
10 gm./ml. glucose 1 mgm./l. thiamine	4·9	4·8	3·8
10 gm./l. glucose 1 gm./l. asparagine 1 mgm./l. thiamine	5·2	5·1	291·2
10 gm./l. glucose 10 gm./l. malt extract	5·2	3·8	337·0
10 gm./l. glucose 10 gm./l. yeast extract	5·4	8·2	346·2

It will be seen from the results of this experiment hat *Fomes noxius* is unable to synthesize either the whole thiamine molecule or its two constituent parts, pyrimidine and thiazole, but is able to combine pyrimidine and thiazole into thiamine. It thus differs from *Fomes lignosus*[5], which has been shown to be able to synthesize at least one part of the thiamine molecule, namely, thiazole. *Fomes noxius* is further unable to grow on pure Knop solution with glucose and thiamine, or with glucose and pyrimidine plus hiazole, if asparagine is absent. It seems, therefore, hat *Fomes noxius* is unable to make use of nitrogen upplied in the form of nitrate.

Work in progress should show whether *Fomes noxius* is able to replace asparagine as a source of nitrogen by other forms of organic nitrogen, or by ammonium.

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Confusion between *Gromia oviformis* and *Allogromia ovoidea*

Gromia oviformis Dujardin, 1835, and *Allogromia ovoidea* Rhumbler, 1903, are marine rhizopods with which the general zoologist is usually acquainted. The former is well known because of its abundance in the inter-tidal zones around the rocky parts of the British coasts, and reference has been made to it in some text-books of invertebrate zoology and protozoology. *Allogromia ovoidea*, although less well known as a living animal, has been prominently figured on many occasions in standard zoological text-books. During the past fifty years a great deal of confusion has arisen concerning these two protozoans, as a result of which incorrect names are now given in several text-books and standard works of reference.

The confusion which exists is shown in the following names given by authors to text-figures, all of which are of the same animal and based on an original by Schultze[1]: *Gromia oviformis* Dujardin[2], *Allogromia ovoidea* Rhumbler[3], *Gromia oviformis* Schultze (= *G. ovoidea* Rhumbler)[4], *Allogromia oviforme*[5,6], and *Allogromia oviformis*[7–10]. All except the second in this list, namely, *Allogromia ovoidea* Rhumbler, are incorrect, and as a result of such misdeterminations the belief has arisen that the two animals being discussed are one and the same. Hence *Gromia oviformis* Dujardin, 1835, is now incorrectly recorded in the "Plymouth Marine Fauna"[11] as "*Allogromia oviformis* (Dujardin) [Jepps, 1926, as *Gromia*]".

A short account of the events relevant to this situation partly explains how the confusion has arisen. Dujardin[12] described and figured a new protozoan under the name *Gromia oviformis*. Schultze[1] later described and illustrated a form as *Gromia oviformis* Dujardin, 1835, which was a straightforward misidentification. This view is supported by the fact that in the same publication Schultze describes as new *Gromia dujardinii*, the illustration of which leaves no doubt that it is the same as *Gromia oviformis* Dujardin, 1835. Here then seems to be a case of double misidentification, leaving an animal described and figured but incorrectly identified as *Gromia oviformis*. This situation existed until Rhumbler[13] recognized *Gromia oviformis* Dujardin, 1835, as a form with filose pseudopodia, and *Gromia oviformis* Dujardin of Schultze, 1854 (the misidentified form), as a form with granulo-reticulose pseudopodia. Rhumbler proposed that the filose forms, namely, *Gromia*, be placed in the Class Filosa, and that the granulo-reticulose forms be included in a new genus, *Allogromia*, within the Class Reticulosa. Rhumbler then erected the new name *Allogromia ovoidea* for that animal misidentified and illustrated by Schultze in 1854.

It was not until 1934, when De Saedeleer[7] discussed Rhumbler's work, that a further change of name was accompanied by any comment, although incorrect names had been used before this date[4,6,8]. De Saedeleer agreed that the *Gromia oviformis* Dujardin of Schultze should be *Allogromia*, but considered, without giving reasons, that a change of the specific name from *oviformis* to *ovoidea* was wrong. He proceeded, therefore, to refer to *Allogromia oviformis*, an unfortunate choice in view of the confusion that has arisen from its usage. According to article 31 of the International Rules of Zoological Nomenclature[14] "a specific name which undoubtedly rests upon an error of identification cannot be retained for the misdetermined species even if the species in question are afterwards placed in different genera". De Saedeleer's claim, therefore, cannot be upheld, and *Allogromia ovoidea* Rhumbler is the correct name for the misidentified *Gromia oviformis* of Schultze, with which the quite different *Gromia oviformis* Dujardin, 1835, is not to be confused.

Quite apart from this account of names, the systematic positions of *Gromia* and *Allogromia* are by no means understood. Sometimes referred to as gromoid forms, they are regarded by some workers as Foraminifera and by others as Testacea. The problem will only be resolved by a fuller understanding of the biology of the animals, of their pseudopodial organization, and of their life-cycles. An extension of the works of Jepps[15] and Arnold[16] to other closely related Testacea and Foraminifera is particularly desirable at this stage in order to give a firmer basis for the distinction between these two groups. At the moment the systematic position depends largely on whether a form produces anastomosing, granular pseudopodia (*Allogromia* and members of the Foraminifera) or pseudopodia which do not, or rarely, anastomose, and are non-granular (*Gromia* and members of the Testacea). Such differences are not always clear cut, and so far there has been no functional interpretation of them. As there are many workers who consider these gromoid animals to be living representatives of a primitive group from which the Foraminifera may have evolved, the answers to these problems should help to clarify the origin of this large and morphologically very diverse order of the Protozoa.

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Sex Ratio in the Golden Hamster before Uterine Implantation

MOST mammalia have a secondary sex ratio nea 100 : 100 with a slight excess for the male sex. A male- and female-determining spermatozoa are bein produced in equal numbers, the primary sex rati would also be 100 : 100, provided that the two kind of sperms are equally able to fertilize. However, a higher mortality-rate in male than in female embryo has been observed in stages in which the sex may be anatomically recognized[1], and is also generally supposed to operate in preceding stages. Based upon this a primary sex-ratio of 150 : 100 has been calculated[1] which must imply a higher frequency of successful fertilizations performed by male- rather than by female-determining spermatozoa.

In order to estimate the sex ratio in as close agreement as possible with the primary one we have determined the sex of a number of embryos before implantation by making use of the morphological differences between the X- and Y-chromosomes. This was possible in the golden hamster, *Mesocricetus auratus*, as the sex chromosomes, which in this species are larger than the autosomes, may be distinguished from each other[2].

Mated females were killed 80–90 hr. after copulation, at which time the embryos were in the blastocyst stage, containing mostly 20–32 cells. The blastocysts were collected by flushing the uterine horns with Tyrode solution, and treated with a 0·45 per cent saline at 37° C. for 15 min. in order to obtain better spreading of the chromosomes at squashing[3]. The blastocysts were then fixed for some hours in absolute alcohol–acetic acid 3 : 1, stained for 15 min. in acetic-lacmoid solution[4], and mounted as squash preparations in neutral Canada balsam.

Using a Zeiss phase-contrast oil immersion objective (mag. 100 ×, N.A. 1·25) camera lucida drawings were made of the chromosomes of well-spread metaphase plates, and the occurrence of X–X- and X–Y-combinations respectively was determined.

As the frequency of metaphase plates was very low—about one plate in every third blastocyst—we introduced a pretreatment of the pregnant females with colchicine[5] in order to increase the number of cells in metaphase at killing. The animals were injected intraperitoneally with 0·025 mgm. colchicine per 100 gm. body-weight 5–8 hr. before being killed. This treatment increased the frequency of metaphases to about one plate per blastocyst, without obscuring the chromosomal morphology.

Until now 51 blastocysts from 39 hamsters have been classified according to sex. Of these, 33 were males and 18 females, giving a sex ratio of 183 : 100, which significantly deviates from 100 : 100 ($t^2 = 4{\cdot}41$, $p < 0{\cdot}05$). The experiments are being continued, and the results from more material will be published in due course.

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G. SUNDELL

Institute of Zoophysiology,
University of Uppsala.
Sept. 8.

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Australian Discoveries of Emperor Penguin Rookeries in Antarctica during 1954-57

The emperor penguin (*Aptenodytes forsteri* Gray) breeds only around the coastline of Antarctica. Many decades elapsed between the time when the birds were first seen and the discovery of a breeding place. The first emperor rookery was discovered at Cape Crozier, on Ross Island, in October 1902 [1].

During Sir Douglas Mawson's Australasian Antarctic Expedition, 1911–13, a rookery was discovered at Haswell Islet and another suspected near the Shackleton Ice Shelf[2]. The latter has been confirmed in 1957 by Russian workers operating from Mirny (personal communication). The German Südpolar Expedition saw large numbers of juveniles in December 1902, when beset near the monolith now known as Gaussberg. However, the presence of a rookery here is doubtful, and the chicks may have come from Haswell Islet. Russian workers operating near Gaussberg in 1957 saw no sign of a rookery.

No further discoveries were made until 1948, when a Falkland Islands Dependencies Survey party found a small rookery on the Dion Islets, south of Adelaide Island, Graham Land[3]. In 1950, a larger one was discovered at Pointe Géologie, Terre Adélie, by a French party from Port Martin[4].

Since that time members of the Australian National Antarctic Research Expeditions have discovered five more emperor penguin rookeries. The first of these was found in October 1954 by a two-man sledging party, R. Dovers and G. Schwartz, approximately 50 miles west of the A.N.A.R.E. base Mawson. It is situated on the eastern side of Taylor glacier (67° 28′ S., 60° 53′ E.) and, unlike most emperor rookeries, is not on sea ice but on land. It contains more than five thousand breeding birds and, partly because of its geographical advantages and sheltered position, appears to have a relatively low chick mortality.

In May 1956 during a flight from Mawson westward to King Edward VIII Gulf, Dr. D. A. Dowie and Flight Sergeant J. Seaton, R.A.A.F., saw a smaller rookery, which was visited in the following spring. It is situated on the southern side of Fold Island (67° 20′ S., 59° 23′ E.) and contains nearly two thousand breeding birds. Studies carried out here in 1957 revealed a very high chick mortality.

The other three rookeries were all discovered during 1957. A very large group of birds was seen from the air by Flight Officer D. Johnston, R.A.A.F., in August 1957, 35 miles east of Mawson at approximately 67° 25′ S., 64° 00′ E. It was visited by K. B. Mather, D. Johnston and me on the next day, by aeroplane, and aerial photographs were taken. A fortnight later R. T. Lee and I visited the rookery by 'weasel'. A count made then confirmed the estimate, made from the photographs, of twelve thousand birds. Random sampling of the population revealed that 71 per cent of the birds were holding chicks. Approximately six hundred dead chicks were found lying on the ice, and probably many more had been buried by snow. Evidence of a great many broken and abandoned eggs was also found, and it may be concluded that at least twenty thousand breeding birds entered the rookery during the breeding season.

This rookery is situated on sea ice which is very thick and rough and is made stable by hundreds of grounded bergs in the vicinity. It is unusual in being about eight miles from the nearest group of islands (Douglas Islands) and 7–8 miles from the mainland. The bergs, however, act as islands do at other rookeries, holding the sea ice from breaking out during the breeding season. No land feature is near enough to give it a name, and it is therefore being named Auster rookery, after the plane from which it was first seen. A very large feeding hole was found six miles south of this rookery at the base of a tilted berg[3].

During September 1957 two more rookeries were sighted from the air by Flight Lieutenant P. Clemence, R.A.A.F. Neither has yet been visited. One is situated at Kloa Pt. (66° 37′ S., 57° 11′ E.), near Cape Boothby, 180 miles west of Mawson. Its size was estimated visually as five thousand when it was first sighted; but this has not been confirmed by any other method. It is situated on sea ice which is held in by a small group of islands.

In the same month, during a flight south-west from the A.N.A.R.E. base Davis in the Vestfold Hills, a

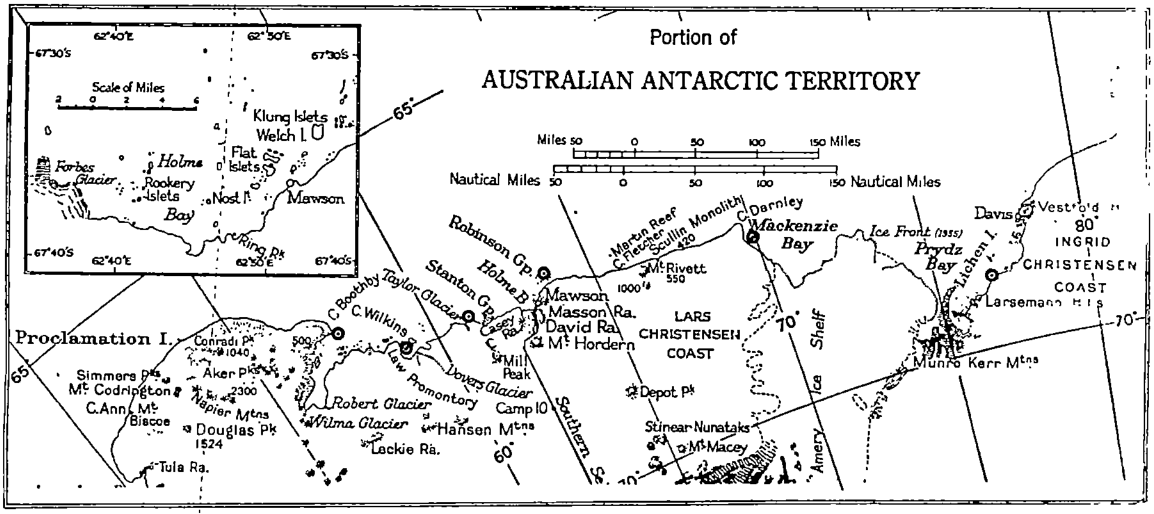

Fig. 1. Part of Australian Antarctic Territory, showing Emperor Penguin rookeries discovered by A.N.A.R.E. From west to east, Kloa Point, Fold Island, Taylor Glacier, Auster Rookery, Cape Darnley, and Amanda Bay

group of birds was seen on the sea ice near a glacier tongue between Davis and the Larsemann Hills (69° 14′ S., 76° 53′ E.). From aerial photographs taken then, the population at that time was estimated to be between one thousand and two thousand birds.

Other parties operating in Antarctica have also reported in personal communications recent discoveries of new emperor penguin rookeries. With the five discovered by A.N.A.R.E. parties it now seems that, although they are by no means numerous, emperor penguin rookeries are no longer a rarity.

Since this communication was drafted, a sixth rookery has been discovered by members of A.N.A.R.E. It is situated in approximately 68° S., 69° 45′ E., among a large group of icebergs on the eastern side of Cape Darnley. It was discovered in August 1958 by Flight Lieutenant H. O. Wilson, R.A.A.F., during a flight from Mawson to Davis. The population is roughly estimated as 5,000.

Richard L. Willing

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July 7.

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The Tide at Shackleton

The sea tide has been measured at the Trans-Antarctic Expedition's Shackleton Base, on the Filchner Ice Shelf in the Weddell Sea. The ice shelf is afloat over some 500 fathoms of water, and is not thought to be aground anywhere within at least 15 miles; the nearest known land is more than 20 miles to the east. In the absence of any fixed point to which the tide could be referred, a Worden gravimeter was used as an altimeter. The gravimeter was placed in a cavern dug 18 ft. below the snow surface, and photographs automatically taken through the eyepiece every hour. A ten-minute exposure was used so as to average out the continual movement produced by unsteadiness of the ice shelf. The Worden is normally used by adjusting a micrometer head until a pointer seen through the eyepiece is in its zero position; in this work the micrometer was left untouched for many days at a time, and the displacement as photographed through the eyepiece was converted into a correction to the constant setting. In this way readings were obtained from August 8 until October 3, 1957. 145 readings were missed, mostly in the early stages and mainly in two big gaps; these were due to my carelessly dropping a key into the works when reloading the camera, and so fusing the lamp.

Allowance was made for the direct tidal variation of gravity (modified by earth tides) as tabulated by Coguel[1]; this produced what are referred to below as 'corrected readings'. Gravimeter drift was calculated by computing a mean reading at each sixth hour, using a formula which takes account of constituents up to sixth-diurnals; these values were then smoothed. The big gaps were filled by fitting a fifth- or seventh-degree polynomial, and using the curve of residuals. Sub-tabulation was then carried out at hourly intervals. Subtracting the 'corrected readings' from these drift values gave figures proportional to the height of the tide above mean sea-level.

These readings were then divided into two 29-day periods, sharing a common day—first, August 8–September 5, and secondly, September 5–October 3. Each period was then subjected to analysis by the method given in "The Admiralty Tide Tables"[2], with the results set out in Table 1. In the averaging, the first period is somewhat arbitrarily given half the weight of the second, because the readings have more gaps and the gravimeter drift was more erratic in the first period. Gravimeter readings were converted to heights by the usual Bouguer formula with an insignificant modification for the acceleration implied by the rise and fall.

Table 1. Shackleton Base. 77° 59′ S., 37° 10′ W.

	M_2		S_2		N_2	
	H	g	H	g	H	g
Period 1	2·14	157°	1·52	180°	0·32	150°
Period 2	1·98	160°	1·44	174°	0·34	148°
Mean	2·03	159°	1·46	176°	0·33	149

	K_1		O_1		M_4		MS_4	
	H	g	H	g	H	g	H	g
Period 1	1·06	348°	0·75	303°	0·02	179°	0·05	279°
Period 2	0·48	342°	1·02	325°	0·07	131°	0·04	206°
Mean	0·67	345°	0·91	319°	0·05	136°	0·04	235°

Central days: period 1, August 22, 1957; period 2, September 19, 1957. Standard time: 4 hr. west. Heights, H, are given in feet.

It can be seen that the constants derived from the two periods are in poor agreement for the diurnals, that the semi-diurnals are well determined, and that the quarter-diurnals are negligible. It is known that there is a spurious constituent of variable amplitude (of the order of 0·3 ft.) and period 40 hr., coinciding with the interval between visits to the cavern to re-load the camera. This is bigger than was expected; but for just that reason makes it plausible that there should be another spurious constituent large enough to produce serious interference with the diurnals, and of period 24 hr. The constants in Table 1 are tolerably compatible with other measurements in the South Orkneys and Graham Land as given by Roberts and Corkan[3], and are well placed to strengthen the co-tidal charts in a little-known area.

I am indebted to the Director of the Liverpool Observatory and Tidal Institute for help in the analysis, and also to Dr. G. P. Woollard of the University of Wisconsin for the loan of the gravimeter and to the British Petroleum Co. for the automatic camera. A full account of this work is to be published in "The Trans-Antarctic Expedition Scientific Reports".

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c/o F.I.D. Scientific Bureau,
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Sept. 8.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 17

INSTITUTE OF ACTUARIES (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. E. N. Mutch: "The Progress of Business Computers in Britain". (Further lecture on December 1.)

ROYAL INSTITUTE OF CHEMISTRY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 5.45 p.m.—Dr. David John Manners: "Recent Advances in the Structural Analysis of Polysaccharides".* (Meldola Medal Lecture.)

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. S. E. Goodall: Presidential Address.

Tuesday, November 18

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. D. A. Sholl: "The Randomness of the Brain".*

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (in conjunction with the BRITISH NUCLEAR ENERGY CONFERENCE, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. W. Binns and Mr. W. J. Outram: "Electrification of the U.K.A.E.A. Industrial Group Factories".

PARLIAMENTARY AND SCIENTIFIC COMMITTEE (in Committee Room 12, House of Commons, London, S.W.1), at 5.15 p.m.—Meeting of the General Committee. 5.30 p.m.: Discussion on "Railway Research and Development" initiated by General Sir Brian Robertson, Bt., G.C.B., G.B.E., K.C.M.G., K.C.V.O., D.S.O., M.C.

RESEARCH DEFENCE SOCIETY (in the Lecture Theatre, Zoological Society of London, Regent's Park, London, N.W.1), at 5.30 p.m.—Mr. Richard Fort, M.P.: "The Irrational in Public Life". (Twenty-seventh Stephen Paget Memorial Lecture.)

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. Hayes: "Bacterial Genetics and Gene Structure".* (Sixth of eleven lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 20, 25, 27, December 2 and 4.)

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Mr. A. B. Merriam: "Commercial and Cost Considerations in Injection Moulding". (Junior Lecture.)

Tuesday, November 18—Wednesday, November 19

INSTITUTION OF GAS ENGINEERS (at Church House, Westminster, London, S.W.1), at 9.30 a.m. daily—24th Autumn Research Meeting.

Wednesday, November 19

INSTITUTE OF METAL FINISHING (at the Charing Cross Hotel, Strand, London, W.C.2), at 10.15 a.m.—Symposium on "Technical Control in Electroplating".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 2.30 p.m.—Discussion on "Atmospheric Chemistry".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. L. A. Longden: "Improving the Efficiency of the Mining Industry" (Cadman Memorial Lecture).

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, Portland Place, London, W.1), at 2.30 p.m.—Symposium on "Analytical Instrumentation Developed at Harwell".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. H. F. Lydall: "The Long-Term Trend in the Size Distribution of Income".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. Redmond: "Television Recording—a Survey of the Problems and the Methods Currently in Use".

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. B. E. Juniper: "Electron Microscopy of Leaf Surfaces".

UNIVERSITY COLLEGE (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. D. A. Denton (University of Melbourne): "The Control of Secretion of the Transplanted Adrenal Gland".*

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Working Stresses and Factors of Ignorance".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1), at 6.30 p.m.—Annual General Meeting. Discussion on "Institute Affairs" opened by Dr. C. C. Hall.

Thursday, November 20

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Lord Medway: "Navigation on the Wing in Total Darkness by means of Echo Among Swiftlets of the Genus *Collocalia* in Borneo". 5.5 p.m.—Symposium on "Chromatography and Taxonomy" opened by Dr. E. C. Bate-Smith, Dr. C. A. Wright, Dr. J. B. Harborne, Dr. A. T. R. Mattick and Dr. N. J. Berridge.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Special General Meeting, Dr. H. Godwin, F.R.S.: "Late-glacial Deposits at Moss Lake, Liverpool"; Dr. H. Godwin, F.R.S., and Mr. E. H. Willis: "Radiocarbon Dating of the Late-glacial Period in Britain" (Studies of the Post-glacial History of British Vegetation, 14).

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Annual General Meeting, followed by Prof. K. A. Hirsch: "Torsion-free Abelian Groups".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. E. M. Shooter: "The Configuration of Proteins in Solution".* (Further lecture on November 27.)

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5.10 p.m.—Scientific Papers.

ROYAL METEOROLOGICAL SOCIETY (in the Conference Hall, County Hall, London, S.E.1), at 5.30 p.m.—Dr. E. T. Pierce: "Thunderstorms". (Popular Lecture for Sixth-form Scholars. To be repeated on November 21.)

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. J. H. Humphrey: "What are γ-Globulins ?"* (Seventh of eleven lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 25, 27, December 2 and 4.)

BRITISH GLACIOLOGICAL SOCIETY (at Bedford College, Regent's Park, London, N.W.1), at 6 p.m.—Mr. D. W. Humphries: "Kilimanjaro and the International Geophysical Year".

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "What is a Cultured Engineer ?"

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, Birdcage Walk, London, S.W.1), at 6 p.m.—Second Lanchester Memorial Lecture.

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. I. L. Freeman: "Scientific Investigation of Clay Pits".

INSTITUTION OF ELECTRONICS (in the Assembly Hall of the University of London Institute of Education, Malet Street, London, W.C.1), at 7 p.m.—Mr. E. Wolfendale: "The Applications of Transistors in Communications and Control Equipment".

OIL AND COLOUR CHEMISTS' ASSOCIATION, LONDON SECTION (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 7 p.m.—Mr. E. F. Redknap: "Reactions of Drying Oils with Hydrocarbons".

PHARMACEUTICAL SOCIETY OF GREAT BRITAIN (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Scientific Meeting on "Applications of Gas Chromatography to Pharmaceutical Analyses".

Friday, November 21

BRITISH PSYCHOLOGICAL SOCIETY, OCCUPATIONAL PSYCHOLOGY SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. T. Lupton: "Problems of Participant Observation".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. George Lowe: "Navigating Across the Antarctic".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Prof. L. L. Beranek: "The Transmission of Acoustic Waves Through Structures" (Thomas Hawksley Lecture).

ANTIQUARIAN HOROLOGICAL SOCIETY (at the Science Museum, South Kensington, London, S.W.7), at 7 p.m.—Mr. H. Alan Lloyd "The Baldewein Astronomical Clock of 1562".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the EAST ANGLIA SECTION and CAMBRIDGE UNIVERSITY CHEMICAL SOCIETY, at the University Chemical Laboratory, Lensfield Road, Cambridge), at 8.30 p.m.—Dr. E. C. Barton-Wright: "The Chemistry of Wines and Spirits".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. F. C. Fraser: "Some Aquatic Adaptations of Whales and Dolphins".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH ASSISTANT, for work on adsorption of polar vapours on ionic crystals—Dr. F. C. Tomkins, Chemistry Department, Imperial College of Science and Technology, London, S.W.7 (November 19).

CHIEF (with a recognized university degree or equivalent in agricultural science and/or science (with physiology as a major subject) and/or veterinary science, and at least ten years postgraduate experience of research work and actively engaged in research in animal physiology, animal nutrition, animal husbandry, or allied subjects) OF THE ANIMAL PRODUCTION DIVISION—The Director, An Foras Talúntais (Agricultural Institute), 21 Earlsfort Terrace, Dublin (November 21).

LECTURER (able to teach organic chemistry to graduate level, conduct research, and preferably with industrial experience and the ability to direct work of postgraduate research students) IN ORGANIC CHEMISTRY in the Department of Chemistry and Biology, College of Technology, Liverpool—The Director of Education, City of Liverpool Education Committee, 14 Sir Thomas Street, Liverpool 1 (November 21).

SCIENTIFIC AIDE, Senior Research Officer grade (with a recognized university degree in agricultural science, at least five years postgraduate research experience in some branch of agricultural science, and preferably a competent knowledge of the organization of agricultural research and experimental work and the conduct of seminars or study courses)—The Director, An Foras Talúntais (Agricultural Institute), 21 Earlsfort Terrace, Dublin (November 21).

ASSISTANT, Grade B (preferably specializing in inorganic chemistry and also some applied science subjects), at Northampton College of Technology, TO TEACH CHEMISTRY up to Higher National Certificate and General B.Sc. standard—The Chief Education Officer, Borough Education Office, "Springfield", Cliftonville, Northampton (November 22).

LECTURER (with up-to-date industrial and/or research experience) IN INORGANIC CHEMISTRY—The Principal, Nottingham and District Technical College, Burton Street, Nottingham (November 22).

TECHNICIAN (preferably with an interest in complex physical apparatus) IN THE RADIOISOTOPES LABORATORY, Pollards Wood Research Station, Chalfont St. Giles, Bucks, to help with investigations on protein and nucleic acid biosynthesis—The Secretary, Chester Beatty Research Institute, Fulham Road, London, S.W.3, quoting "Isotopes" (November 22).

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics, physical chemistry or biochemistry, and at least three years postgraduate or other approved experience) at the Ministry of Agriculture, Fisheries and Food, London, for work on nuclear problems in relation to agriculture and food—The Civil Service Commission, 30 Old Burlington Street, London, W.1, quoting S.4900/58 (November 27).

CHAIR OF METALLURGY—The Registrar, The University, Manchester 13 (December 8).

GULBENKIAN RESEARCH FELLOW to investigate certain aspects of the teaching of physics or chemistry in schools—The Registrar and Secretary, The University, Bristol (December 15).

LECTURER or ASSISTANT LECTURER IN MATHEMATICS at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 15).

LECTURER or SENIOR LECTURER IN ANIMAL NUTRITION at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 15).

READER IN NUCLEAR ENGINEERING at Queen Mary College, Mile End Road, London, E.1—The Academic Registrar, University of London, Senate House, London, W.C.1 (December 16).

SENIOR LECTURER IN MATHEMATICS at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 16).

ECOLOGIST (man, with a first- or second-class honours degree, and preferably with some knowledge of statistics), to join a team studying marine plankton, using continuous plankton recorders—The Officer-in-Charge, Oceanographic Laboratory, 78 Craighall Road, Edinburgh 6 (December 20).

LECTURER and an ASSISTANT LECTURER IN GENETICS—The Secretary of University Court, The University, Glasgow (December 31).

LECTURER IN VETERINARY PATHOLOGY AND BACTERIOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

LECTURER (with a degree in engineering, preferably with honours, and experience and interest in the field of thermodynamics and heat engines) IN MECHANICAL ENGINEERING at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

PROFESSOR OF PHARMACOLOGY—The Registrar, University Registry, Oxford (December 31).

DRUMMOND FELLOW (Senior or Junior, depending on qualifications) for Research in Nutrition—The Honorary Secretary, Drummond Trust, University College, Gower Street, London, W.C.1 (January 31).

ASSISTANT, Grade B (preferably with the ability to teach horticulture), TO TEACH BOTANY to B.Sc. (General) and G.C.E. Advanced and Ordinary levels—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex.

BIOCHEMIST, Basic grade (preferably with experience in routine medical biochemistry)—The Group Pathologist, Mental Hospitals' Group Laboratory, West Park Hospital, Epsom, Surrey.

BIOCHEMIST (with B.Sc. or M.Sc.), for research on insulin antagonisms in blood plasma—Dr. Vallance-Owen, Department of Medicine, University of Durham, King's College, Newcastle-upon-Tyne.

CHEMIST or BIOCHEMIST (preferably with a knowledge of carbohydrate chemistry) IN THE PHYSICAL CHEMISTRY DEPARTMENT, for research in immunological problems covering a wide range of interest—The Secretary, Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh 9.

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SENIOR LECTURER (with good academic qualifications and suitable experience in the teaching of a branch of advanced mathematics) IN MATHEMATICS—The Secretary and Clerk to the Governors, Borough Polytechnic, London, S.E.1.

SENIOR SOIL CONSERVATION OFFICER (with a university degree or a recognized diploma in agriculture, and not less than ten years' experience in soil conservation work, preferably in East Africa) in Barbados to undertake the direction of conservation work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD 63/28/06.

ZOOLOGIST (with a good honours degree in zoology and competent to plan zoological subjects for either television or film production), to carry out production and research work in conjunction with the Television and Film Unit located at the London Zoo, Regent's Park—The Secretary, Zoological Society of London, Regent's Park, London, N.W.1.

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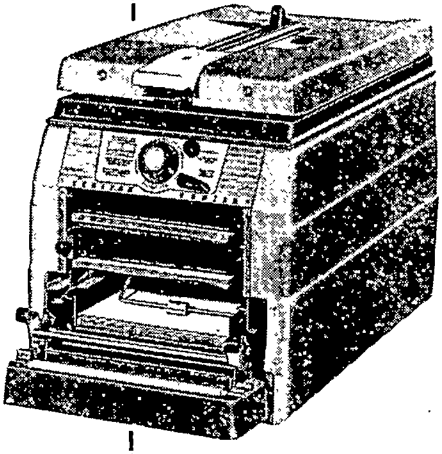

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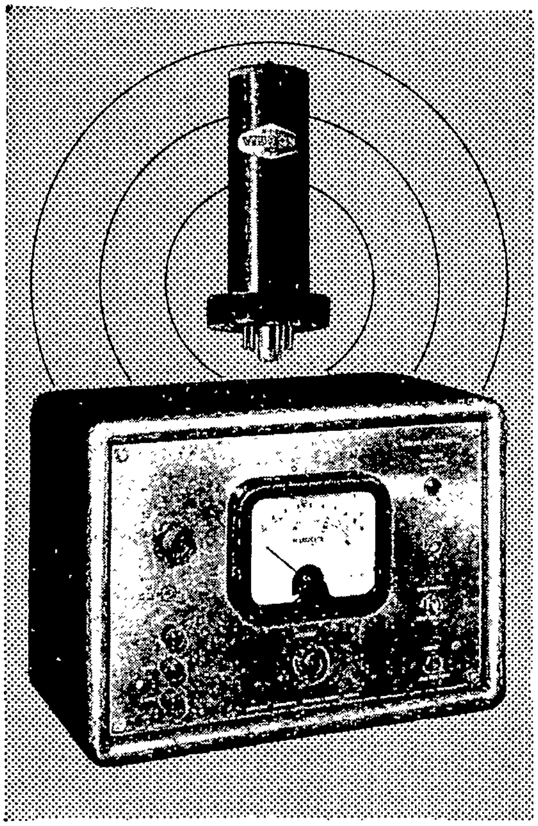

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INTERNATIONAL CO-OPERATION IN SCIENTIFIC RESEARCH

THE address in which the Right Hon. R. C. Casey, the Minister for External Affairs and Minister in Charge of the Commonwealth Scientific and Industrial Research Organization, Australia, asked the General Assembly of the United Nations, on September 25, to make more concerted world action to stimulate scientific research for the welfare of mankind a priority task of the Economic and Social Council in 1959 has strong claims on the attention of both scientists and technologists. Mr. Casey was particularly concerned with the time-lag between scientific discoveries and their application to production and human welfare; but he began with a reference to the International Geophysical Year and to the value of the artificial Earth satellites, not only as a spectacular advance in technology but also as a potential source of new scientific data about the regions of space immediately surrounding our planet. Australia has taken full advantage of its special opportunities for research in optical and radio-astronomy which arose from its situation in the southern hemisphere, and her scientists have co-operated actively with scientists in other parts of the world, including the United States and the U.S.S.R. The new giant radio telescope to be built in Australia will be the largest and most far-reaching piece of equipment of its kind in the world.

Some of the possibilities of this new field of knowledge of outer space, involving cosmic rays and the harnessing of these and other phenomena, might as yet be unsuspected, but it is essential that the serious decisions ahead of us in this field should be made by mankind and not just by individual nations. Outer space should be recognized as a field of international concern before it is too late; it cannot be regarded like the high seas, in which outside territorial waters anyone can do what he likes, and which have been the arena of competition for naval supremacy. The world's scientists have met the challenge of outer space, and Mr. Casey urged that it is for the political leaders to meet the challenge it presents in their own field of competence.

While outer space, nuclear energy and electronics are probably the fields in which current scientific and technical advances are the most spectacular and impressive to the ordinary individual, they are, he continued, only part of a much wider revolution in man's position in the universe resulting from research and invention during the past fifty years in practically every field of science and technology. Those fifty years have witnessed developments in the sciences as well as in medicine, agriculture and engineering much greater than in the preceding thousand years. This direct contact with such activities, both in Australia and in many countries of Asia under the Colombo Plan, has greatly impressed Mr. Casey with what has already been achieved by men of science and with the promise of the future. The tide of research and invention is flowing ever more strongly, and it is essential to consider the probable course of scientific development in the next fifty years. For the first time in human history, the whole world might have within its reach the attainment of high standards of material welfare and security.

In a passage reflecting H. A. L. Fisher's well-known reference in his "History of Europe" a generation ago to the abounding miracle of science, Mr. Casey added the qualification "provided we can live together in peace, and concentrate our energies upon the co-operative application of man's advancing knowledge to the control of our physical environment". On this ground he suggested that science must inevitably figure to an increasing extent in the activities of the United Nations and in the Specialized Agencies. There is, indeed, already a very considerable range of scientific activity to be found, for example, in the World Health Organization, the Food and Agriculture Organization, the Technical Assistance Administration, the United Nations Educational, Scientific and Cultural Organization, the International Atomic Energy Agency, the World Meteorological Organization and the Conference on the Peaceful Uses of Atomic Energy. Moreover, the International Geophysical Year is itself a striking and encouraging demonstration of the importance and practicability of international scientific co-operation in the attack on specific problems that call for the combination of several scientific disciplines or techniques.

Nevertheless, Mr. Casey believes that the United Nations could do still more to stimulate and encourage scientific progress and the application of its results, and could play a larger part in planning the strategy of scientific advance, particularly when advance is needed on many fronts and when the world's scientific resources are unevenly distributed. First, he suggested, in regard to research, that it would be useful for the United Nations to look at the total picture to find gaps, to look for promising openings, and to consider the adequacy of the men and facilities available for research that should be undertaken. Next, he suggested, the United Nations could consider the dissemination of scientific knowledge and the results of research, with a view of reducing the excessive lag between scientific discovery and its widespread dissemination and application. Thirdly, he referred to the place of science in education and to the need to recast our ideas as to the proper content of a liberal and humane education.

In this context, Mr. Casey pointed out that the problem of education is much wider than the production of qualified scientists to meet the shortage in particular directions in so many countries. Nor is it enough for educational authorities to add a further subject to the curriculum, to push in a science subject and to take out one of the humanities. He believes that no one is educated who does not know something about science or who knows nothing but science.

Mr. Casey recognizes that all these questions in varying and sometimes overlapping ways fall within the sphere of the United Nations and some of the Specialized Agencies, but he believes that a more concerted approach is needed and that the appropriate body for this is the Economic and Social Council. In view of the relatively little attention given in the past to the idea of a concerted approach to the field of natural science, Australia considers that the Economic and Social Council should give it priority for 1959.

Finally, Mr. Casey suggested that the General Assembly should request the Economic and Social Council to examine the role of the United Nations and the Specialized Agencies in relation to the advance of science and to consider methods of stimulating research in most-needed directions. It should also examine methods of achieving a wider application, dissemination and understanding of new discoveries, taking account of the great inequalities that exist in the scientific resources of different countries.

Apart altogether from the merits of Mr. Casey's particular proposals, his address indicates keen interest in and real understanding of science by the Australian Minister for External Affairs. Moreover, his speech follows a remarkable address on modern science and civilization which the Australian Prime Minister, the Right Hon. R. G. Menzies, delivered to the Australian Medical Congress last March. The trend of thought in both addresses is strikingly similar, particularly in relation to the significance of the Earth satellites, their plea for devotion of the immense resources of science to the service of peaceful human needs and their recognition of the critical importance of a balanced education in which science and the humanities both find a place. Whether or not this is coincidence, it at least suggests that some of Australia's leading political representatives are likely to bring to the consideration of any issues in which scientific or technological considerations are involved genuine awareness of these considerations and a capacity for a balanced judgment.

Mr. Casey did not refer specifically to the discussions of a decade ago on the question of establishing United Nations Research Laboratories, but his recognition that little research could or should be done by the United Nations itself or in the Specialized Agencies, and that the great private and national research foundations and the universities should not be set aside or their work duplicated, suggests that he is fully aware of the practical difficulties and of the criticism those proposals received. Strangely enough, although in the meantime it has become even more apparent in certain fields of research that only co-operative effort will suffice to install and operate economically the expensive equipment necessary, this was not noted by Mr. Casey. The corollary, that no one country can hope to carry out at once all the scientific and technological research that is desirable, quite apart from other essential scientific activities, is the strongest argument for Mr. Casey's thesis, and, whatever its ultimate fate, it should at least contribute to an awareness notably lacking in Great Britain, in the Government and without.

As regards research, Mr. Casey did not advance any fresh arguments. It is, or should be, the function of existing bodies, such as, for example, the Advisory Council for Scientific Policy in Great Britain, to be looking continually for gaps in the front of research, for promising openings, and to assess the adequacy of man-power and facilities available. It is hard to see how it would be any easier on the international plane to find and bring together the men competent for this difficult task. Nor can effect be given to these recommendations without substantial change in the whole political climate and without political representatives of the calibre and outlook of Mr. Casey and Mr. Menzies. Moreover, it is probably still true, as Sir Edward Appleton has pointed out, that the unions organized under the International Council of Scientific Unions are the most useful instruments of international co-operation in science.

A more promising field appears to be in the dissemination of scientific knowledge, for here it is the political factors that have largely been responsible for the major obstacles. They could be removed by fuller understanding, as the success of the Conferences on the Peaceful Uses of Atomic Energy has indicated, but to reduce the time-lag between a scientific discovery and its widespread application can depend on economic and educational factors at least as much as on those that are directly political. There is, undoubtedly, a growing body of experience here that could be pooled, and it might well be that exploration of this proposal of Mr. Casey's could benefit Great Britain directly by bringing home to the Government the importance of certain factors in the dissemination of scientific information and the efficient use of trained man-power which it has been apt to neglect or disregard.

As Mr. Casey himself recognizes, this question is closely related to his third proposal regarding education. On this factor, more than anything else, depends the effectiveness of much of the work already undertaken under the Colombo Plan or through the Technical Assistance Administration to assist in scientific and technical developments throughout the world. If we can solve the problem of education on the lines he indicates, we shall have gone far to ensure the more efficient use of our existing resources in science and technology, quite apart from making it easier to expand that effort. Moreover, it is on the basis of such an educational policy that we can best hope to see the international co-operation that is undoubtedly required in the attack on some of the problems with which the widening horizons of science confront us, and the sustained support that the successful execution of an agreed programme demands. It should not be forgotten that it is one thing for the appropriate programme or project to be agreed and another for the resources to be allocated for its initiation. Even on a national scale, that is not very easy, and it is unlikely to be easier on the international plane. No less important, however, is the continuing support of the project until it is complete. The difficulty which international organizations have hitherto experienced in securing such support from year to year warrants little optimism that, without considerable raising of the standards of education, integrity and objectivity in political circles at all levels, we can hope for the co-operation and sustained support required for an attack on any major scientific or technological objective on the scale necessary in the modern world. Mr. Casey's proposals may, however, lead to a clearer understanding of what is possible if the individual nations are willing to pay the price ; and they remind the scientist and technologist once more that he has responsibilities in this matter of education which are not simply professional but those of the citizen, too.

LIFE OF HENRY ARMSTRONG

Henry Edward Armstrong, 1848–1937

The Doyen of British Chemists and Pioneer of Technical Education. By Dr. J. Vargas Eyre. Pp. xix+325+15 plates. (London : Butterworths Scientific Publications, 1958.) 30*s*.

THIS biography of H. E. Armstrong by one of his former pupils, Dr. Vargas Eyre, details the life of a vivid personality spanning the remarkably eventful years from 1848 to 1937. He began the study of chemistry at the Royal College of Chemistry just before Hofmann left to return to Berlin. Edward Frankland succeeded to Hofmann's chair in 1865 when the idea of chemical valency was emerging and before Kekulé's benzene formula was generally known. But before Armstrong left the stage, valency had received an explanation in terms of the electron, and the three-dimensional structures of such complex compounds as the sterols had been elucidated. Truly a remarkable advance in a single life-time, and the recent synthesis of the diamond in a tetrahedral anvil at pressures of 100,000 atmospheres and temperatures near 2,000° C. shows that the forward march continues.

In 1865 public sewers were almost unknown, and water pollution rampant. Frankland was one of those charged to tackle the problem and he set 'H. E.' to devise a method for estimating the pollution. During this period he attended lectures on geology by Ramsay, on physics by Tyndall and those on the place of science in education by Huxley. Later, Frankland urged him to go to Leipzig to work with Kolbe, and he did so in 1867 and remained nearly two and a half years working for his doctorate. On his first day in Leipzig, Kolbe suggested that Armstrong should examine the mixture formed on sulphonating phenol. Kolbe was also a forceful exponent of both attack and defence on chemical questions, and all the guiding principles in Armstrong's subsequent career had thus been fixed before he was twenty years old : purity of food and especially of milk and beer with the great problems of agriculture and health (Frankland), an abiding interest in geology (Ramsay), the life-long crusade on the teaching of science and its importance to industry (Huxley), the dominating role of sulphonation in his research work and the whole crowned by a dynamic character and a powerful debater (Kolbe). Apparently such characters no longer emerge from the mould in this plastic age.

On returning from Germany 'H. E.' started his teaching career at St. Bartholomew's Hospital and continued in this part-time post for twelve years. It is said he never received more than £50 a year for the work. Already in 1875 he was junior secretary of the Chemical Society, and when the senior W. H. Perkin retired he activated and came to dominate the Society after 1880. He was one of the first four professors appointed to the new City and Guilds Central College in 1884, and his research output began to mount. Many papers appeared on the sulphonation of naphthalene, others were on the terpenes, and particularly camphor. In 1888 he advanced the quinone theory to account for the colour of organic compounds, and both with pen and in debate he vigorously championed the role of water in electrolysis.

Possibly his many wide interests prevented him from making any great advances in the laboratory, but great credit is due to his school for producing chemists such as F. S. Kipping, A. Lapworth, T. M. Lowry, W. J. Pope, and W. P. Wynne among others. His forward vision embraced the importance of crystallography in chemistry and led him to appoint Henry Miers to lecture to his students on the subject.

The lack of suitable posts for chemists in industry at that time was reflected in the fact that he never had more than about a dozen senior students, and this probably influenced the authorities to close his chemistry department in 1911. After nearly thirty years of great service to the Central College he was given notice to quit without pension.

Armstrong was a fiery crusader who occupied the centre of the stage in many causes, but his advocacy of the teaching of science in schools also showed considerable statesmanship, as witness the paper he presented on the subject to the British Association in 1889 and its sequel in the successful trials of the heuristic method at St. Dunstan's College and Christ's Hospital. It is not too much to say that his work for education profoundly influenced science teaching in all English-speaking countries. It gives much food for thought that in spite of the urge for technical education and the application of science to industry in the fourth quarter of last century, these very problems are a matter of life and death to us in the third quarter of this century.

Dr. Eyre's account of Armstrong's life has clearly been a labour of love, and in the interest of the history of science it is well that it has been made. Perhaps it is rather long even for such an eventful life, and if much of the minor matter had been sacrificed Armstrong's great record of service to science and education would have shone all the clearer.

G. R. CLEMO

FRAUDULENT DOCUMENTS

Suspect Documents

Their Scientific Examination. By Dr. Wilson R. Harrison. Pp. viii+583. (London : Sweet and Maxwell, Ltd., 1958.) 84*s*. net.

THE book under review is a very important contribution to the published knowledge on the examination of suspect documents, particularly as it is the first complete review of the opinions of an acknowledged British expert on the subject.

Fraudulent documents have existed as long as genuine documents, and the problem of their detection has been of considerable importance to States and individuals. This problem existed before science was sufficiently advanced to assist in its solution and, therefore, there grew up a tradition of examination of documents based on superstitious credulity and with no scientific background whatsoever. It is against this tradition that the modern scientific document examiner has to fight constantly in courts of law and in public opinion. A. S. Osborn in the United States was the first to show successfully the necessity for the recognition of scientific principles in this sphere, and his "Questioned Documents", first published in 1910, is the classic on the subject. Other books of his, such as "The Mind of the Juror", indicate the difficulty experienced by the document examiner in divorcing the mind of the layman from preconceived ideas and directing it to the scientific facts which are demonstrably present in the examiner's report. In the 1920's and early 1930's, C. A. Mitchell in Great Britain most actively pursued and reported the search for scientific methods of examining documents, and a number of other authors have written on various aspects of document work; but little has been reported on the comparison of handwriting and typewriting, although considerable advances have been made. While Ordway Hilton in 1956 described American experience, the volume under review fills the gap from the British point of view, which has been created for a modern evaluation of existing techniques, and the book must therefore be read by all who are interested in these matters.

The book may be divided into four parts. First, the scientific examination of documents for alteration or fraud. This includes modern techniques such as, for example, the chromatography of inks. Secondly, the photographic techniques used in documentary analysis for various purposes are discussed, with the difficulties arising in making photographs for record purposes, and also the manifold special techniques required to detect alteration, erasure, obliteration, indentation, mutilation and all the other ways of ill-treating documents. Thirdly, handwriting and typewriting comparisons; these are extremely fully and authoritatively dealt with. Fourthly, the many requirements for obtaining the maximum use in court of handwriting and typewriting evidence are given, commencing with advice to the police in securing the best available material and ending with advice to counsel on the special problems arising in the presentation of handwriting evidence.

Each section is exhaustively and comprehensively treated and contains a mine of information for those wishing to understand the principles and methods involved.

There is some repetition, admitted frankly by the author, much of which is necessary both to ensure the completeness of each individual section and also to emphasize salient points. Nevertheless, I found that the repetition in Chapters 8–15 on handwriting and typewriting comparison, which the author undoubtedly has nearest to his heart, detracts from the enjoyment in reading the chapters.

The book is beautifully and carefully produced, and the illustrations are clear and informative. Only four minor proof-reading errors were detected, which is very few considering the size of the book. The index is comprehensive, and a glossary is included; this appears to be neither necessary nor helpful to the public for which the book is written. L. C. NICKOLLS

THE LAND OF AUSTRALIA

Land Utilization in Australia

By Wadham and Wood. Third edition by Sir Samuel Wadham, R. Kent Wilson and Joyce Wood. Pp. xxii + 344 + 77 plates. (Melbourne: Melbourne University Press; London: Cambridge University Press, 1957). 40*s*. net.

THE first edition of this book, by Prof. Wadham and the late Gordon L. Wood, then lecturer in economic geography in the University of Melbourne, was completed in 1938 and published in 1939. The second edition, completed in December 1947, appeared in 1950, so that the three editions mark approximately ten-year intervals. In the meantime, the book has become an indispensable standard work. The story is now brought up to date partly with the help of Kent Wilson, who is lecturer in economic geography in the University of Melbourne. The senior author has become emeritus professor, and been knighted; Gordon Wood's daughter contributes a valuable new series of maps and diagrams.

These decades have witnessed some remarkable, sometimes curious, changes in land use in the continent. The early White settler had found the land of Australia more nearly virgin than any territory on Earth, for the aborigines, never numerous, neither tilled the soil nor kept herds of animals. They lived frugally by hunting and gathering edible fruits and roots with a minimum effect on the flora and fauna. If their presence resulted in occasional bush fires it is likely that at least as many fires were caused by lightning or other natural causes. At the same time the isolation of the continent had led to a balance between a peculiar flora and a peculiar fauna different from that anywhere else in the world. The physical environment of relief, climate and soil is repeated elsewhere, but the biotic environment is unique. It presented, and continues to present, difficult and challenging conditions to the spread of Western methods of both arable and pastoral farming. The decades preceding the uniting of the States as the Commonwealth of Australia in 1901 were characterized by a vast extension of cultivated acreage and of flocks and herds, and by a spirit of ebullient optimism. This optimism was part of the process of nation-building exemplified by the publication of such works as "Australia Unlimited". Lone voices, such as that of Prof. Griffith Taylor, in the nineteen-twenties, which dared to suggest there existed a dead heart of desert which could not be revived, were howled down. To-day the difficulties are realized: the strength and importance of physical factors, above all availability of water, are fully recognized.

The authors survey the historical sequence of settlement—wool, then wheat, then dairying, then irrigation agriculture, with each in turn coming to occupy a definite but by no means fixed position in the whole. The present position is that the total of cropland, including sown pastures and orchards, is only 2·5 per cent of Australia's 3,000,000 square miles. Although 55·8 per cent is claimed as natural pasture and rough grazing, much has a very low carrying capacity. The depression of the 'thirties had reduced the initiative and morale of the countryside, the varying phases of war demanded adaptations of farming which were quite impossible. At first Britain wanted all the wool, but no shipping was available for fruit and wine and little for wheat.

Then Britain, as Danish and other supplies were cut off, demanded vast quantities of dairy produce and bacon. The arrival of a million Americans resulted in an insatiable demand for orange juice and milk. The post-war period has seen its violent changes too—the 1951 inflationary demand for wool, and then the collapse of prices in 1952. Despite the vast reserves of land the present trend is rural depopulation, and the stupendous growth of Australian cities. Mechanization, with consequent reduction of labour force, and intensive development of the more favoured lands are characteristic of the present: the future may hold many surprises. L. DUDLEY STAMP

THE PAREXIC ANALYST

Applied Analysis

By Prof. Cornelius Lanczos. (Prentice-Hall Mathematics Series.) Pp. xx+539. (London: Sir Isaac Pitman and Sons, Ltd., 1957.) 55*s.* net.

APPLIED analysis—Prof. C. Lanczos suggests the adjective 'parexic'- -is described by him as "the analysis and design of finite processes which approximate the solution of an analytical problem". The 'pure' analyst is, say, concerned with the existence of approximations to arbitrary functions by special types of functions, such as polynomials, to within an arbitrary ε, the 'numerical' analyst wishes to calculate the polynomial in some specific case, for an assigned numerical ε: the 'parexic' analyst is more interested in construction, and economy of construction, minimization and estimation of error, than in existence or calculation. Such a classification can scarcely be clear-cut; and the problems of the parexic analyst must in any event be modified by the invention of new computing devices, but a label for those interested as much in the theory as in the processes of numerical analysis may be useful. In some respects, the aims of the book resemble those of Householder's "Principles of Numerical Analysis", but Prof. Lanczos deploys on a broader front, in less detail and in a more discursive style. A sound knowledge of calculus and some acquaintance with the complex variable and Cauchy's theorem will will enable the student to read the book with ease.

The chapter subjects give a good indication of the main content, though not of the richness of the material: algebraic equations; matrices and eigenvalues; large-scale linear systems; harmonic analysis; data analysis; quadrature methods; power expansions. From a book full of interest, a selection of special items, even if depending on personal preference, may be worth making. Bernoulli's method is prominent in the chapter on algebraic equations, and complex roots, so important in stability criteria, receive much attention. The geometrical interpretation of matrices and eigenvalues, to illustrate their algebraic treatment, should greatly help the novice. The 'spectroscopic' method, which eases the calculation of small eigenvalues, is particularly dear to the author, since it allows him to exploit his favourites among the orthogonal polynomials, those of Chebyshev; indeed, these keep turning up aptly throughout the book in quite surprising places. The study of the inversion of the Laplace transform is most valuable, in the light of recent technical requirements, and Chebyshev plays a part. Numerical integration is centred on Gaussian methods, with a modification designed to avoid the troublesome evaluations at irrational points without serious loss of accuracy; the author ignores Chebyshev in this connexion, though his rules are, I believe, still much employed by naval architects. In expansion problems, the construction of expansions which shall furnish reasonably good approximations over a whole range, rather than very good at one end and poor at the other, is helped by using orthogonal polynomials, and here, as also in the related problem of speeding up convergence, the Chebyshev polynomials are again prominent, Finally, introductory historical paragraphs to each chapter help in setting the scene and preparing the reader for what is to follow. T. A. A. BROADBENT

CHROMOSOMES

Looking at Chromosomes

By John McLeish and Brian Snoad. Pp. vii+88 (48 plates). (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 16*s.* net.

THE quality of a book of photographs must rest not on the technical standard of the photographs, for this is taken for granted, but on the suitability of the subject and on the discrimination and skill of arrangement. Chromosomes are certainly photogenic, but can their cyclical changes in shapes and movement be captured in a series of post-mortem stills? In trying to find an answer it is difficult not to make the unfair comparison with the enthralling films of live chromosomes that show every movement, relevant and irrelevant, in a most dramatic way.

The photographs in "Looking at Chromosomes" are so well chosen and arranged that they show the changes in shape and most of the relevant movements of the chromosomes. They cannot show the movement of chromosome arms or the unorderly jostling of the paired chromosomes for their place on the metaphase plate of meiosis which have been revealed in moving films. But the essentials for interpreting chromosome form and movement and their significance in heredity are clearly shown. The unique feature about the series is that the cyclical changes in mitosis in roots, in meiosis in the male pollen mother cells and female mother cells are all taken from one organism—the regal lily. This is no mean achievement, for most organisms have an obscure part of the chromosome cycle which is technically difficult to show. The short text of explanation emphasizes the genetic implication of the chromosomes. Two minor criticisms may be made here. The cytoplasm is described as "a highly viscous fluid". This is only true sometimes; often the cytoplasm is little thicker than water. The constancy of the complement of chromosomes is not so universal in differentiated cells as the over-simplified statement in the last chapter implies.

The addition of a simple time-scale of the chromosome cycles would add greatly to the completeness of the general picture.

For those who do not have a moving film of chromosomes or a projector, "Looking at Chromosomes" is quite the best and only complete account in photographs of our heritage—the chromosomes.

D. LEWIS

ELECTRON MICROSCOPY IN BIOLOGY

By PROF. R. D. PRESTON, F.R.S.
Department of Botany, University of Leeds

INVESTIGATION of biological structures smaller in dimension than the resolution of the light microscope has until comparatively recently been confined to a relatively few laboratories throughout the world. This was because the physical principles involved were such as to be unfamiliar to the majority of biologists and because the equipment required was normally not found in their laboratories. Apart from the replacement of visible light by ultra-violet light in the conventional type of light microscope (increasing the resolving power by a factor of about 2) the methods used were those of polarization microscopy and X-ray diffraction analysis. With neither of these two methods was it possible to produce directly a visual image of the structures being investigated; a complex mental process intervened between the observations made and the structure delineated. The methods suffered, moreover, from other serious drawbacks. Only structures which were crystalline could be investigated, that is to say, substances with atoms and molecules arranged in a regularly repeated order in space. The smallest objects which could be studied were microscopic in size, and the observations made upon them frequently enabled only an 'average' structure over the whole specimen thickness to be determined. Again, whereas in the light microscope the smallest dimension directly observable is of the order of 1000 A., the power of X-ray diffraction analysis lies in the dimension-range of a few angstroms, and even the method of low-angle scattering enables the form of an object to be calculated only up to a dimension of a few hundreds of angstrom units. This left a wide gap of structure completely outside the scope of investigation.

In electron microscopy, biologists have been presented with a tool which, while not free of its own drawbacks, and not in any sense replacing the older methods, has removed some of the particular disadvantages inherent in these methods. Moreover, the preparative techniques and the observational methods are basically those of light microscopy, in which biologists already excel. This newer technique has therefore thrown the field of submicroscopic structure open to biologists, and the opportunity thus given has been taken up vigorously by biological departments throughout the world. This constitutes a revolution in histology perhaps of equal rank to that heralded by the development of the compound light microscope during the past century. The meeting held recently by the Linnean Society on applications of electron microscopy to biology, the first meeting in Britain confined solely to biological applications, demonstrates clearly the rapid progress which has already been made in this field, so rich in promise.

The use of this comparatively new instrument is not without its dangers, and these fall especially heavily upon the biologists. The specimen to be observed must be sufficiently thin to be penetrated by the electron beam. At best, therefore, the specimen thickness can be no more than 0·1μ and preferably, for high resolution, not more than 100–200 A. It is observed in a high vacuum, and is therefore completely desiccated, and the absorption of electrons causes a considerable rise in temperature. With biological material particularly, therefore, the investigator must at every stage, both in preparing the specimen and during observation, be prepared for the development of artefacts. At all stages and with all specimens it is highly desirable that results of electron microscopy should, in the first instance, be checked against observations with the older and more familiar techniques.

Observations in the electron microscope can be interpreted with the least ambiguity with specimens of robust material the structure of which is already fairly well known. Such a material is the plant cell wall. Some cell walls lend themselves to preparation for observation by relatively mild mechanical treatment, and the wall of *Valonia* vesicles is particularly convenient. This was historically the first organism yielding an electron micrograph of relatively untreated cell wall material[1]. There rapidly followed a succession of publications[2] on other wall material usually prepared by grinding in a blender. It soon became clear that the first observation, that the cellulose consists of long narrow threads (in *Valonia* of the order of 200 A. in diameter), is of universal application in the plant kingdom (Fig. 1). This harmonized completely with the already known structure of cellulose in the form of long molecular chains of β1–4 linked glucose residues lying, sometimes more, sometimes less, parallel to each other. With *Valonia*, in particular, these long threads—termed 'microfibrils'—were found to be arranged parallel to each other with sufficient accuracy and to be sufficiently crystalline to give an electron diffraction diagram in the electron microscope (Fig. 2). This diagram fully confirmed that the microfibrils consist in the main of long molecular chains of glucose residues lying parallel to each other and in large part spaced in a regular crystalline space-lattice. This combination of electron microscopy with electron diffraction analysis of identically the same specimen observed in the electron microscope offers the biologist a most powerful tool in the study of material to which these methods can be applied. Not only can a visual image be recorded but the molecular structure of the material can also be determined, a combination which has already led to some most spectacular results[3], including the demonstration of the clear necessity for a re-determination of the unit cell of cellulose derived by the method of X-ray analysis.

The more recent use of ultra-thin sectioning and of surface replication[4] has served largely to confirm structures already revealed for a wide variety of cell walls by the older methods of polarization microscopy and X-ray diffraction analysis[5]. Moreover, the visual delineation of structure in minute pieces of material which electron microscopy allows has enabled considerable advances to be made in the question of the synthesis of cell wall materials. Thus, it has been

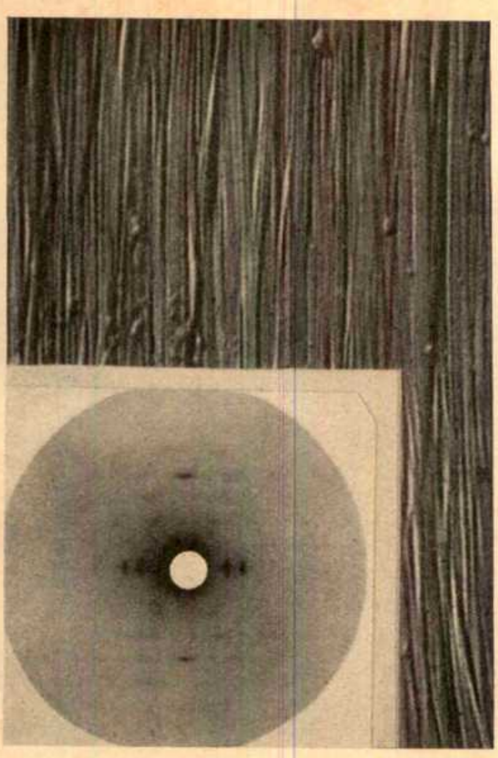

Fig. 1. Electron micrograph of a single lamella of the wall of the vesicle of *Valonia ventricosa*, palladium–gold shadowed (× 40,000) Note the parallel microfibrils occasionally twisted

Fig. 2 (inset). Electron diffraction pattern of a lamella similar to that shown in Fig. 1, but unshadowed, and in correct orientation with respect to Fig. 1. Note the line of arcs along the equator (parallel to the shorter edge of the page) perpendicular to the length of the microfibrils in Fig. 1

reported[6] that, whenever a wall lamella is observed which is just being laid down by the cytoplasm, the wall surface is covered by a series of aggregations of corpuscular bodies from which cellulose microfibrils appear to diverge. The observation of the first formed wall around swarmers has already produced results of outstanding importance from this point of view[7], and present and future work on this material is of the greatest promise. Again, once more in harmony with the older work, it has turned out that the microfibrils in the walls of growing cells are arranged more or less transversely to cell-length, particularly in the innermost wall lamellæ abutting upon the cytoplasm. It is claimed that the outermost layers of such cells, away from the cytoplasm, are constituted of microfibrils which are more nearly randomly or even axially oriented. On the grounds of these electron microscopical observations, Roelofsen[8] has proposed a hypothesis to explain the relationship between the expansion in area of the cell walls of growing cells with the growth of the cell. On this hypothesis, in a freely growing cell, the microfibrils are first laid down by the cytoplasm more or less transversely to cell-length and, as the cell elongates, this lamella, moving outwards through the wall as newer lamellæ are laid inside it, becomes elongated through the agency of turgor forces so that the microfibrils become progressively oriented more and more away from the transverse. While such a mechanical explanation of the reaction of the wall to growth processes has not met with universal acceptance, and while the hypothesis makes no attempt either to explain how the microfibrils come to be arranged transversely or how it is that cells elongate rather than increase uniformly in dimensions, it does include principles which cannot be ignored in discussions of the growth process.

Considerable attention has been paid to the construction of plasmodesmata in primary walls and pits in secondary walls[9]. It has become clear that plasmodesmata are indeed penetrations of the wall by cytoplasm which runs among rather loosely packed microfibrils, and that the membrane of bordered pits consists of a loosely woven network carrying the central torus when a torus occurs. Along more or less the same lines, it has similarly been shown by observation of ultra-thin sections that the pores in sieve plates of *Cucurbita*[10] and of other species[11] are completely filled with cytoplasm, a simple observation which seems to rule out all existing theories of phloem transport except those involving the use of metabolic energy.

Among those whole organisms which can readily and simply be observed in the electron microscope, the viruses and the bacteria are, of course, outstanding. The beautiful electron micrographs of Wyckoff and others have shown how readily the shape and size of virus particles can be demonstrated[12] as well as the beautifully regular way in which these particles become associated to form crystals[13]. The bacteria have been examined both whole and in ultra-thin section[14] so that these minute organisms are now open to critical examination.

It is, however, perhaps in the cytoplasmic organization both of plants and of animals that electron microscopy, and especially the observation of ultra-thin sections, reaches greatest power. Here structures are being revealed which were not known before the development of electron microscopy, and it is therefore in this field that artefacts have most carefully to be excluded. It is impossible in this short space to mention even briefly all the important observations which have already been made in this field, and the choice of illustrative material here is therefore quite arbitrary. Considerable attention has been paid to those elongated organs known as flagella which by movements of various kind propel motile cells through the substrate. Whereas with motile bacteria[15] the flagella appear to be simple fibrils, all flagella so far investigated in higher plants and animals[16] appear to be multiple and to contain eleven separable strands (Fig. 3). Ultra-thin transverse sections of these flagella have shown that these eleven strands are arranged in a specific manner, two central strands being surrounded by nine others arranged more or less in a cylinder. In the spermatozoids and other motile cells of some plants the flagella are clothed with a mat of fine fibrils—to which the German name 'flimmer' is applied—and occasionally with spines and hooks in an intriguing array. These observations are even at present of considerable taxonomic importance and may well pave the way for an understanding of motility in these motile cells. Current research is aimed at tracing the connexion between the bases of these fibrils and the internal organelles of the parent cells.

The cytoplasm itself has provided a wealth of structural detail (Fig. 4) and the larger granular inclusions have naturally been the first to demand attention. Within chloroplasts, for example, it has been confirmed that the chlorophyll lies in the so-called 'grana' and that both the grana and the ground substance are laminated. High-resolution microscopy has further demonstrated that these

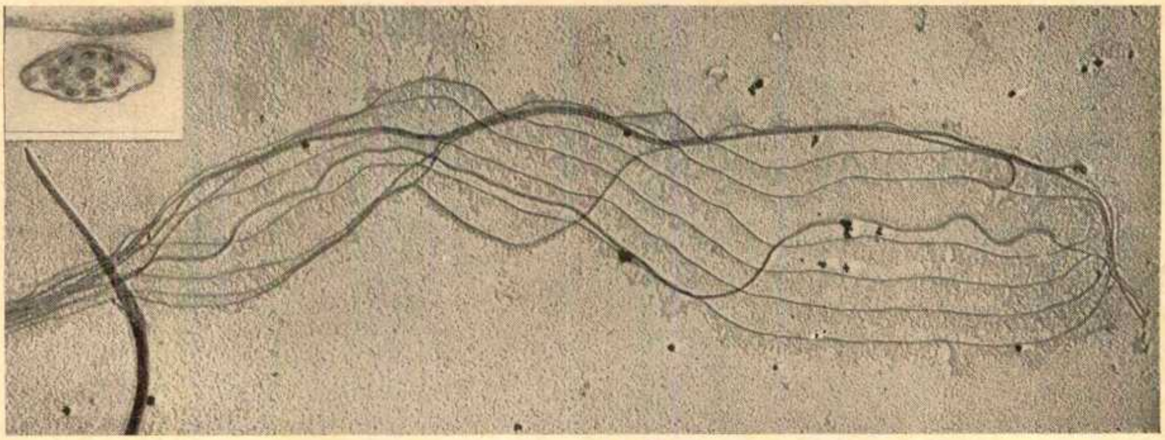

Fig. 3. Electron micrograph of an intact and dismembered flagellum of a *Sphagnum* spermatozoid (× 5,500). (Manton and Clarke, 1952) Inset: Electron micrograph of a transverse section of a flagellum of a *Sphagnum* spermatozoid (× 38,000). (Manton, 1957.) (Photographs prepared by B. Clarke)

lamellæ are often double and folded in complex ways[17]. This again confirms the opinion often expressed, based upon the physiological observations of the absorption spectra and fluorescence spectra of chlorophyll in solution in the leaf and as a sol. Mitochondria have similarly been shown to possess a membrane from which peg-like protrusions stand out towards the inside of the granule[18]. These protrusions have been shown in several instances to be double and may be infoldings of a membrane. The question of the presence of a membrane around the nucleus in the resting phase has been answered once and for all. Both in plants and animals the nucleus has a clearly marked membrane which is double and which is perforated at frequent intervals[19]. Little definitive evidence has yet been presented in electron micrographs concerning the structure of chromosomes.

The structure of the cytoplasm surrounding the more obvious granular inclusions has proved to be more complex than speculations, based on observations under the light microscope and the physical properties of the material, had led us to expect. It is undoubtedly in this field that the greatest care has to be taken in preparing the specimen in order to prevent the development of artefacts. The general appearance of the more organized cytoplasts is that of a series of vacuoles limited by fine membranes of the order of 100 A. or less in thickness which are probably double. This reticulated appearance gives the impression that the cavities lying between the membranes are empty. It must, however, be realized that the complicated imbedding technique, including the imbibition of methacrylate monomers, may cause solution of cytoplasmic constituents and therefore their disappearance from sections. It should be realized, too, that the *p*H of the fixing fluid is highly critical and that the only criterion at the moment for the suitability of any particular fixation method lies in the clarity of the resulting electron micrograph. More complicated regions such as the Golgi apparatus[20] have clearly been identified and the structure worked out. The widespread appearance has been noted of a well-marked reticulate system consisting either of vesicles or long narrow canals or tubes or plates bounded by double membranes, named by Porter and Kallman the 'endoplasmic reticulum'[21], provisionally interpreted as being associated with conduction or circulation of various substances.

Electron microscopy has thus made it clear that one common theme seems to run through the structure of the whole of the cytoplasm and its inclusions, namely, that the structure is based on a lamellated system, and it seems that biochemical activity is specifically associated with lamellæ. This is, of course, entirely in harmony with the generally accepted view, based on physiological evidence, that metabolic processes occurring in cells are associated at some stage with an adsorption phenomenon at surfaces.

In addition to this direct attack on biological problems by the method of electron microscopy, it must not be forgotten that the electron microscope is playing a great part in an indirect way, too, in the

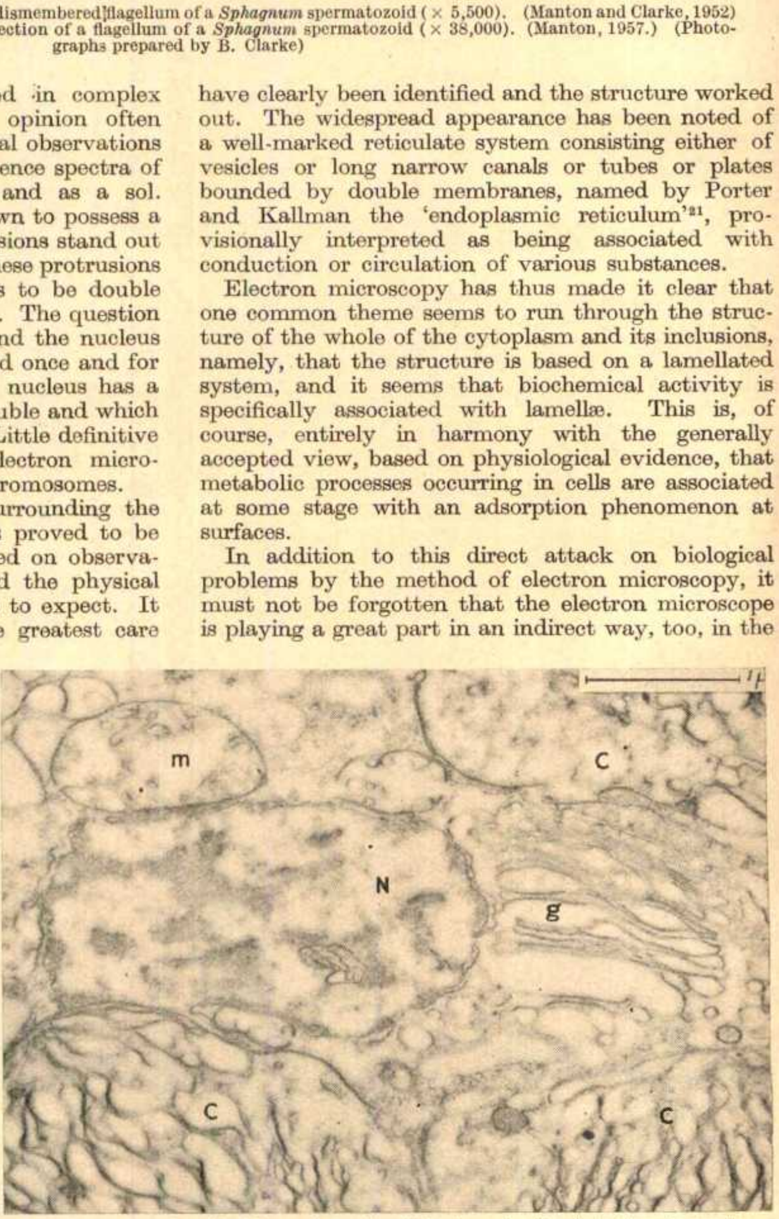

Fig. 4. Section of a cell of *Chrysochromulina chiton* (a marine flagellate) showing nucleus (*N*), parts of three chromatophores (*C*), mitrochondrion (*m*), a Golgi area (*g*), etc. Unshadowed (× 22,500). (Parke, Manton and Clarke, 1958. Photograph prepared by B. Clarke)

development of the biological sciences. Thus, the localization of ribonucleic acid or of enzymes and enzyme systems on cytoplasmic particles of submicroscopic dimensions[22] could not have been achieved without the simultaneous electron microscopical observation of the particles and the verification that the material under investigation contained no other bodies. Again, in the chemical fractionation of biological material the results are on a much surer foundation now that it is possible to check the purity of the extracts by electron microscopy. One case in point refers to the extraction of plant cell wall material[23] in which the extraction was watched under the electron microscope at each stage, so that not only could the chemical composition of the material be given but also the site from which the various components had come could be located with some precision.

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CONSERVATION OF NATURAL RESOURCES

THE International Union for the Conservation of Nature and Natural Resources held its sixth General Assembly (and seventh Technical Meeting) in Athens during September 10–19, under the presidency of Prof. R. Heim of Paris. The main theme of the technical discussions was that of soil and water conservation, one so wide that it was necessary to subdivide the papers submitted (by delegates from more than thirty countries) into groups dealing with the technical aspects of evaporation and run-off, the use of vegetation in the control of erosion, the effects of dams on habitat and landscape, and the development of aquatic resources, as well as the ecological solutions of specific water and soil conservation problems. In a special address to the assembly, Dr. R. Scott Russell gave a thoughtful and interesting analysis of the problems set by the influence of atomic radiations and wastes on the vegetation cover.

The rapid development of ideas of water control was well illustrated by attempts to see in evaporation from land surfaces with different types of vegetation cover, variants in the eddy-diffusion systems which might exert comparatively little influence on the over-all evaporation-rates of a considerable tract of country. Much attention was directed to the influence of the vegetation or other cover on the soil temperature and indeed to the energy relations of the evaporating surfaces, and the physical conditions which determined how rapidly water ran off or sank out of reach in the soil. H. C. Perriera, in particular, showed the importance of studying 'rainfall acceptance' and the conditions governing the structure of soils in this connexion. W. Robyns thought that in tropical regions the role of a permanent vegetation cover in maintaining the hydrological equilibrium was of the first importance because of its influence on the temperatures and structures of soils, and on biologically induced fertility. Thus, although several lysimeter studies from various parts of the world were reported, the results from them were generally regarded as open to various interpretations, giving little final assistance in solving the physical problems of semi-arid soils.

Considerable attention was also devoted to the use of dams to impound water for irrigation or for general industry. The losses of water occasioned by different sizes of dam and diverse types of dam distribution were compared with those from other forms of utilization, with some tendency to conclude that water was best used where it fell, particularly in regions requiring protection from desiccation or soil erosion. The value of fish culture in impounded waters as a source of protein food was regarded by some speakers as a compensation for any water losses.

It was made extremely clear that conservation of water is of the first importance in most countries, particularly in the highly industrialized and the arid, and that the problems involved in wise planning and utilization are rarely those for the engineer alone but are likely to involve not only the physicist and pedologist but also the meteorologist, plant physiologist and ecologist, often in conjunction with forester and agriculturist.

Much attention was naturally directed to problems in the Middle East, North Africa and the Mediterranean region generally. Several speakers adopted a historical approach to conservation of water and erosion of soil, very appropriate against the background of ancient Greece. They saw in deforestation and in wasteful and ignorant methods of land use the reasons for the decline of Mediterranean civilizations, the lessening of cultivable land and the spread of semi-desert conditions in this region. The arguments developed and evidence produced were in marked contrast to the well-known views of Huntingdon and others which base changes of this type on a supposition of climatic desiccation. G. V. Jacks threw still another idea into the arena, the conception that a society's socio-economic status determines whether it is 'fertility-destroying' or 'fertility-creating'. "Thus the capacity of the world for food production is limited not by land or soil-fertility but by the productive capacity of its urban industries," which will be balanced by an equivalent energy in agricultural development. "A wealthy city will create a productive soil," and the relative scarcity of large cities in the Mediterranean might thus imply low productivity.

The technical papers almost always led to general discussions involving the world background of rapidly increasing populations and the over-riding problem of how to marry the need for increased production with the preservation of natural resources, either as a long-term economic need or for scientific or amenity aims. As this assembly showed, the Union is becoming a meeting-ground between those whose aims lie chiefly in production and those who are mainly interested in the protection of Nature and natural resources. Edward Graham remarked that those who emphasize the need for protection or for production are respectively contrasting, on one hand, the necessity for the maintenance of the stability of natural environments and their organic life and, on the other hand, the manipulation of habitats in order to obtain the organic products required. It is becoming evident that these rival aims are nearer than is often thought, for the 'marginal' or more extreme habitats need protection if they are to be at all productive, and, in contrast, high production can only be based on those habitats which are able to withstand manipulation, that is, are ecologically so 'buffered' as to permit a considerable latitude in treatment. Conservation, therefore, consists essentially in the identification and classification of environments followed by the development of protective and stabilizing forms of production for ecological systems which are unstable. A paper by forestry representatives of the Food and Agriculture Organization was of interest in this connexion, because it described how, in scrubby protection forests in semi-arid regions, the use of branches and small timber for the production of charcoal in specially devised kilns had made it possible to maintain the necessary permanent vegetation cover and yet produce a necessary fuel for the inhabitants.

The multiplicity of considerations involved in conservation often makes it difficult to popularize the basic conceptions. While it is evidently the role of scientists, on one hand, and of government, on the other, to deal with multiplicity of factors and of aims and with their integration, conservation and the "real future of all natural resources (again to quote Edward Graham) lies in the hands of the peoples themselves, for it is they who till the fields, graze the flocks and cut the forests. If the people are to care for the land they must have a stake in it. For this reason, ownership of the land, or at least a share in the proceeds of its production, becomes important".

If the science and technology of the management of resources are to be brought within the people's reach, local organizations are required not only to unify the efforts of the local community but also to utilize, in full, the technical assistance which may be made available from government. Only by such means can the work done become part of the pattern of living and culture of the community. The role of education is equally important, and both these aspects of the problem were considered to be particularly urgent in under-developed countries, where the uncontrolled growth of populations is likely to lead to over-exploitation and to the irreversible destruction of natural assets and amenities. Education in such societies will involve not merely the spread of technical information but also the need for the indigenous inhabitants to acquire a feeling of responsibility for the resources of their land and its wild life. This must be coupled with the presentation of necessary ideas on conservation both to industrialists who may seek to exploit present conditions at the expense of the future and to administrators who must acquire a long-term outlook with a capacity to supply leadership in balancing immediate demands for exploitation against the need for preserving the natural heritage for the future. In discussing the measures which might be adopted to bring about these threefold aspects of education, the assembly concluded.

W. H. PEARSALL

ADVANCES IN THE USE OF RADIOISOTOPES

Medical Uses

THE developments which have occurred in the use of radioisotopes in medicine, as doubtless in other departments of science, have usually been associated with technical developments on other lines also. The availability of radioisotopes as a tool stimulates the imagination and ingenuity of those using it. This has been reflected in the past in counter techniques ; but the development of chromatography, scintillation mapping, methods of section-cutting, autoradiography and other techniques are all reflected in the papers submitted to the second International Conference on the Peaceful Uses of Atomic Energy.

In biochemical work one of the most important developments has been the use of tritium, which, by virtue of its soft beta-radiation, permits the localization of uptake of a labelled compound, thymidine, within 1μ of the structure taking it up, so that accurate information is obtained on chromosome duplication and the timing of synthesis of deoxyribonucleic acid, nucleolar synthesis of deoxyribonucleic acid and cell migration from crypts to villi in the intestinal epithelium (*P*/842). The necessity for correction for the absorption in protoplasm and the effects of nuclear flattening was stressed in another paper (*P*/323), since these factors must influence the effect on the photographic emulsion. Only metabolic reactions can detach the tritium from the labelled thymidine, but tritium in high concentration may give large doses of radiation locally as well as having different metabolism from hydrogen.

Much of the Russian work on animals has focused attention on the central nervous system, and in this respect they have shown (*P*/219) that methionine-^{35}S is an essential amino-acid for the cells of the brain and is synthesized into protein. An interesting investigation of protein synthesis (*P*/846) demonstrated the relatively sudden synthesis in 6·5 min. of the ferritin molecule by using valine-^{14}C. It is emphasized that it occurs directly from amino-acids and not from polypeptides or larger molecules. A relatively comprehensive review of protein metabolism determined by radioisotope methods was given (*P*/77). The investigation of detailed metabolic processes was exemplified by the demonstration of the citric acid cycle in yeast using carbon-14 dioxide (*P*/1563), the relationship of phosphoryl choline, phosphoryl ethanoline and phosphoryl serine into phospholipids in the central nervous system (*P*/2318) and the use of phosphorus-32 and paper chromatography to show the stimulating effect of glucose on phosphorus-32 turnover in muscle, kidney, liver and intestinal mucosa (*P*/1006).

In connexion with the skeleton, phosphorus-32, calcium-45 and sulphur-35 have been used to follow the metabolic processes of healing fractures (*P*/1500). The rapidity of concentration of calcium-45 in bone (commencing in 45 sec.), together with the rapid burying of calcium-45 and strontium-90 in the inaccessible regions of bone crystal (*P*/2397) and the demonstration of high concentrations of these isotopes in young Haversian osteons, all throw fresh light on the dynamic nature of bone metabolism. The metabolism of ruminants (*P*/813), the synthesis of milk (*P*/812) using carbon-14 labelled compounds and the isolated udder (*P*/852) have been investigated in detail. In connexion with hæmatology, the relationship of vitamin B_{12} labelled with radiocobalt to the intrinsic factors of the pig's stomach has been studied (*P*/1050), while in rats, incorporation of iron-59 has been used to study the factors influencing the formation of erythropoietin and to fix the kidney as its site of production (*P*/847). Survey autoradiograms of sections of whole mice have shown the distribution of various labelled drugs throughout the body (*P*/164), while in goats and cattle the metabolism of tritium-labelled hexœstrol has been demonstrated (*P*/280).

Several communications were concerned with radioiodine studies, and of these the relationship of the depression of central nervous activity due to damage to the pituitary or hypothalamus to inhibition of the thyroid seems important (*P*/2202). This has been investigated by the use of the defensive conditioned reflex, which has no effect in the absence of both the hypophysis and the adrenal. It would seem desirable that the conditioned reflex should be developed and used in other countries besides the U.S.S.R. as a tool for studying cortical function. Using this technique, it is stated that 0·5 μc. sodium-24 was a threshold dose for a rat, while to shorten the defensive conditioned reflex time to its initial level in 8–10 days a dose of 50 μc. of sodium-24 was effective (*P*/2056). Even tracer doses of iodine-131 are said to have significant effects.

Diagnostic measures using radioisotopes have become very numerous and varied. Iodine-132, with a half-life of 2·3 hr., permits early repetition of tests and, for the same precision, gives smaller doses to gonads, bone marrow and thyroid (*P*/277). It also makes possible the day-to-day following of conditions of iodine metabolism in the patient. Its preparation from tellurium-133 (half-life 77 hr.) is quite practicable. Much work has been done to elucidate thyroid metabolism. The etiology of thyroid disease and the scintillation mapping of the uptake of iodine have been improved. Pulmonary ventilation and circulation can be investigated alongside a cyclotron which can produce oxygen-15 with a half-life of 2 min. Decay of oxygen-15 is by emission of a positron, and the annihilation gamma-radiation can be measured by a scintillation counter externally (*P*/278). Small regions of the lung can be investigated, so that the method is an advance on bronchospirometry. Analysis of cardiac action has been advanced also by intravenous injection of radioiodinated serum albumin and also large-particle radiogold colloid. This latter is held by the lung capillaries and so normally excludes the circulation of the left heart (*P*/1385). Inhalation of krypton-85 and methyliodide-^{131}I has been used with the object of delivering a radioisotope to the left heart, so as to study the pure left-heart circulation (*P*/215) by external counting. Liver function has been studied by counting over the liver after the administration of rose-bengal labelled with iodine-131, since the liver cells take up the dye (*P*/870). The use of a new substance, di*iso*propylphosphofluoridate, for labelling blood cells has the advantage that it is not eluted from labelled cells and is chemically inert. The life of human erythrocytes, 110–130 days, was confirmed, and leucocytes and platelets, since they also contain esterases, also bind di*iso*propylphosphofluoridate (*P*/557). The use of iodine-131 and diiodofluorescin for improving accuracy of localization of brain tumours (*P*/2069) was reported in connexion with electroencephaloscopy. Automatic scintillography is becoming more widely used, and (*P*/1219) facilitates the mapping of organs containing gamma-radiators. The possibilities of quantitative estimation of elements subjected to neutron bombardment have been exploited in the case of arsenic determinations in hair, finger nails and tobacco (*P*/69).

Consideration of the radiation hazard has been the rule in almost all the techniques discussed. The physician and the investigator alike recognize their serious responsibilities for this aspect of work with radioisotopes. Methods of measurement have advanced so much that small trace quantities are the role, even for the scintillation scanning techniques. The measurement of bremsstrahlung from phosphorus-32 is a definite advance (*P*/1222) which may develop into a useful method.

In the therapeutic use of radioisotopes, no radically new procedures were reported. The selective uptake of boron compounds by brain tumours has been previously reported, and the work is being improved in detail. Boron-10 and lithium-7 have been concentrated to an effective degree in brain neoplasms, so that neutron capture can give a selective radiation effect on the tumours (*P*/881). The five-year results of the use of radiogold colloid intraperitoneally for ovarian cancer show a 45 per cent survival without symptoms from fifty-one patients. The results are the best yet published (*P*/234) for any series of ovarian carcinoma including all stages. Interstitial uses of radiocolloids of gold, yttrium and phosphorus have been explored by several workers. Uses of cobalt-60 for intracavitary treatments have been developed further (*P*/973). Attempts at destruction of the pituitary gland by grains of radiogold (*P*/68) and by radioyttrium pellets (*P*/874) are not by any means uniformly successful nor free from complications, although a stereotaxic method seems less liable to complications than fluoroscopic methods. Teletherapy units containing cobalt-60 have been developed so as to provide the advantages of high penetration, without excessive damage to skin and bone. There is no reason for expecting bone marrow to be spared by these high-energy beams. The differences in techniques necessary to use these advantages were discussed (*P*/67) and the relative merits of cæsium-137 as an alternative were mentioned (*P*/2403). At the same time, it was stated that 314 units containing in all 179,000 curies had been distributed by March 1958 to eighteen countries by Canada and the United States alone. Cæsium-137 for short-distance beam units was described (*P*/579).

Some results, for example, 45·4 per cent alive without symptoms for two to five years of cases of living cancer and 31 per cent of cases of cancer of the œsophagus alive without symptoms from one to three years (*P*/2056), are better than one finds in most countries.

F. ELLIS

General Uses

THE sessions on isotope applications at Geneva covered a very wide field. There were few revolutionary disclosures, perhaps because only a year has elapsed since the Unesco meeting on isotopes was held in Paris. Isotopes are now employed in some sixty different countries, and the papers accepted amounted to about fifty in each session, although only eight were read. The standard of the papers delivered was uneven, suggesting that their selection was made partly from political considerations and not solely on their scientific merit. The variety of topics covered makes classification under headings difficult, and in a brief report one can only suggest trends and pick out items here and there that caught the eye.

The monetary savings made by use of isotope applications run to large figures. Libby's estimate for 1957 savings in the United States is 500 million dollars (*P*/2390). A Russian survey gave their figure for 1957 as 1·5 billion roubles. The United Kingdom figures are still being analysed and are likely to be in the region of £1 million saved.

Of the materials produced, there have been improvements both in quantity and quality. A much greater range of labelled organic substances is offered. These are prepared by standard methods of synthesis, by biosynthesis using growing plants or algae to incorporate the labelled atoms, or by radiation labelling. This latter method attaches the labelled atom by an exchange reaction usually following ionization caused by gamma- or beta-bombardment (*P*/284). There is a significant increase in the use of tritium as a label. Iodine is still the medical tracer most used, its scope being widened by the short-lived isotopes now made (*P*/277). Many countries have plans to step-up their production of fission products from their power reactors. Cæsium-137 will be used for commercial radiations in million-curie quantities in a few years (*P*/831). The use of krypton-85 is expected to grow for applications in the oil industry and for exciting luminous signs and lamps (*P*/2520). Strontium-90 will also be on the same scale; but so far no one has suggested a satisfactory method of containment of this toxic substance without impairment of its beta-radiation. The demand for cobalt-60 is increasing steeply. There are 160 cobalt-60 therapy installations of 1,000 curies in the United States alone. Within a few years there will be several massive radiation cells in operation using 10^5 to 10^6 curies each.

In the field of massive radiation, greater caution was noticeable than in the predictions made at the first Geneva Conference (*P*/65). Preservation of foodstuffs has been found to have a number of drawbacks in practice. Some excellent Russian work has been done on the preservation of potatoes and the chemical effects of the radiation on the tubers (*P*/2131). Feeding trials in the U.S.S.R. have led the Ministry of Health there to permit irradiated potatoes to be sold and eaten by the public (*P*/2308). Other papers reported promising results from ante-mortem injection of adrenalin into meat to be irradiated by gamma-radiation (*P*/258). This arrests the enzyme activity and avoids unpleasant changes in flavour and smell.

Graft and block polymerization of plastics under gamma-bombardment may soon produce some important products (*P*/826). The United States papers reported a styrene–polyethylene ion-exchange membrane that has been used for purifying brackish water (*P*/2390). The possibility of coating some of the synthetic fibres to reduce their static attraction is of considerable interest to the textile industry. Improvements are reported from catalysts which are subjected to gamma-bombardment (*P*/2380).

A wide variety of industrial applications were reported at Geneva. In oil-well logging, radioactive methods are used as a standard technique. In 1957, eight million metres of oil boreholes were logged with neutrons. The movement of silt in harbours and estuaries can be measured with great sensitivity by depositing radioactive substances (*P*/2357). New methods of attaching the activity to sands and stones are being evolved, among them a Portuguese system of immersing sand in a radioactive silver solution which is later reduced by sunlight on the sand grains (*P*/1820). Measurement of flow in rivers, sewers and pipelines seems capable of application even on the largest scale. The recent method of total counts developed by Hull is a powerful variation of the usual technique (*P*/817). For tracing water through different strata, labelling by tritium, iodine or by cobalt complexes may show advantage in preventing the absorption of activity in the particular soils (*P*/1613).

Radiometric analysis is suggested as a control against toxic gases in the atmosphere (*P*/2390). The gas is made to react stoichiometrically with a radioactive reagent, and the resulting active product may be used to detect the gas quantitatively.

Several countries reported using tracers for mixing and flow studies to follow wood chips in pulp mills, and bulk flow in cement kilns, glass-works, etc. (*P*/1101). In most cases the measurement need only be made once, but it can give the information on hold-up and throughput-time vital to such processes.

Once again the papers from the U.S.S.R. showed their wide applications to the metallurgical industry (*P*/2218). Papers ranged from tests on mixing and melting times in steel furnaces and ladles to the study of micro-structure of alloys using autoradiography (*P*/2236).

In chemistry and biochemistry, the variety of labelled compounds has led to better understanding of chemical reactions and especially in carbohydrate, fat and protein metabolism. Thymidine, a precursor of deoxyribonucleic acid, has been labelled with tritium, so permitting autoradiography with clear enough resolution to study single cells or chromosomes (*P*/323). Further work continues on the mechanism of photosynthesis using chromatography and autoradiography. One method for following the path of oxygen starts with enriched stable oxygen-18. Later on, a chromatogram is bombarded by protons with the reaction $^{18}\mathrm{O}(pn)^{18}\mathrm{F}$ to allow the radioactive fluorine-18 to be measured (*P*/2520). Alpha-cameras were described for measuring thin paper, tissue or other microtome sections (*P*/1621). The surface densities measured were 10^{-14} gm./cm.^{2} with the claim that this could be improved to 10^{-15} gm./cm.^{2}.

A novelty was a Japanese method of using autoradiography to develop fingerprints by using formaldehyde or stearic acid labelled with carbon-14 on the protein traces in the print (*P*/1342). As the autoradiographs may require a week to develop it seems of questionable value for the speedy apprehension of a criminal.

In agriculture, work continues on the uptake of plant nutrients and the behaviour of ions in different soils (*P*/287). Of particular interest is the question of foliar sprays versus conventional root feeding (*P*/2390). Systemic insecticides and their subsequent fate in the plant are traced in the same way. Several nations described improvements to crops by selection of mutated strains. Gustafsson gave details of Swedish Pallas barley developed since 1947, which is an erectoid type having stiff straw and gives yields a few per cent better than its parent Bonus (*P*/2468). A Russian paper gave details of improvements in mutated types of streptomycin, aureomycin and terramycin which would save considerable amounts of money (*P*/2436). Even at the time of writing, some papers are still not available, and one looks forward to the publication of the official proceedings so as to re-read in comfort many of the contributions.

W. S. EASTWOOD

PROGRESS OF THE RUSSIAN EARTH SATELLITE *SPUTNIK* 3 (1958 δ)

By D. G. KING-HELE

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THE third Russian Earth satellite was launched on May 15, 1958, into an orbit which, like that of its predecessors, was inclined to the equator at an angle near 65°. On entering its orbit the satellite split into five pieces. The most important piece, carrying the instruments and radio transmitter, was roughly conical in shape, 12·3 ft. long and 5·7 ft. in diameter; it weighed 2,926 lb., including 2,134 lb. of scientific equipment, and was designated 1958 δ 2. The second and largest piece, 1958 δ 1, was the empty shell of the rocket which had carried the satellite into orbit; its shape and size have not been revealed. The other pieces, which have been observed only infrequently, are the nose cone and two side shields of the satellite.

Initially, the period of revolution of *Sputnik* 3 was 105·98 min. and the orbital eccentricity 0·111. The height above the Earth varied between 122 n.miles (226 km.) at perigee and 1,014 n.miles (1,879 km.) at apogee, with perigee occurring when the satellite was going north at a latitude of 50° N. Though *Sputnik* 3 and its rocket began in almost identical orbits, they were soon separated by the action of air drag, which had a much greater effect on the rocket than on the denser instrumented cone. Fig. 1 shows the period of revolution of the cone (curve *A*) and the rocket (curve *B*), with values of orbital eccentricity marked on the curves. The total life-time of the rocket is likely to be rather less than seven months, whereas that of the instrumented satellite is expected to be about twenty-one months

Though the rocket is due to make its final descent through the atmosphere early in December, its exact date of descent cannot be confidently predicted, be-

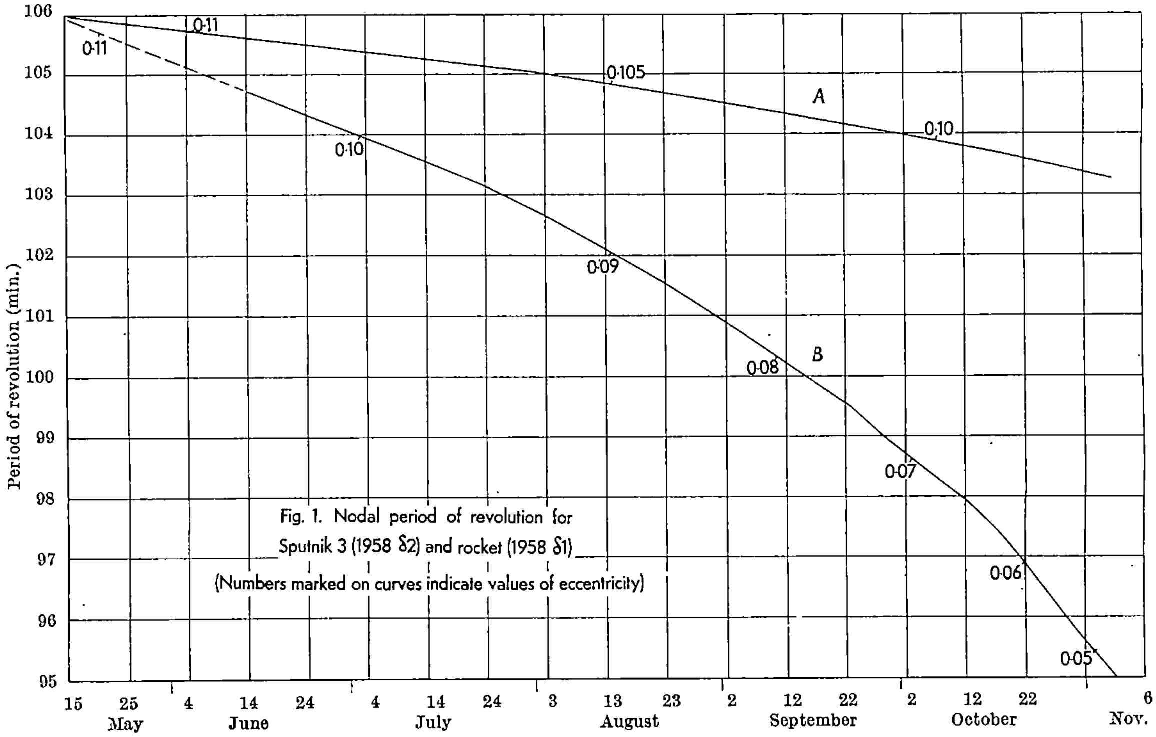

Fig. 1. Nodal period of revolution for Sputnik 3 (1958 δ2) and rocket (1958 δ1) (Numbers marked on curves indicate values of eccentricity)

cause the period has been decreasing in an irregular manner. The daily change in period, instead of increasing smoothly, has behaved more like a step-function: the change was about 2·4 sec./day from June 20 to July 20, about 3·2 sec./day from July 31 to August 19, about 4·0 sec./day from August 23 to September 22, about 4·8 sec./day from September 24 to October 10, and about 7·4 sec./day from October 19 to November 5. The daily change in period of the instrumented satellite has also exhibited sharp variations, though these are not so well charted, because observations have been fewer and the irregularities smaller: the change in period was about 0·7 sec./day initially and had risen to 1·1 sec./day by October 20.

An irregular decrease in period implies irregularities in either the effective cross-sectional area of a satellite or the effective air density near perigee. If, as is likely, irregularities in air density are occurring, does the density depend on latitude, on a parameter dependent upon time, or on some other influence? Comparison of *Sputnik* 3 and its rocket suggests that the density is more likely to be varying with latitude than with time[1]; but there is, as with[2] *Sputnik* 2, some indication of an oscillation having a period of about twenty-seven days, which might be attributed to lunar tides; and solar disturbances may have some influence[3].

The rocket has been a bright object in the night sky, occasionally reaching stellar magnitude − 2 on favourable transits. Because it is rotating, its brightness has fluctuated greatly, sometimes by a factor of more than 100. The period of the fluctuations has shown a slow increase, from 8·5 sec. in mid-July to 9·0 sec. at the end of August and 9·5 sec. at the end of October. The instrumented satellite is, as its designation 1958 δ 2 implies, less bright than the rocket, and observers have found it fickle in its

Table 1. ORBITAL DATA FOR *Sputnik* 3 (1958 δ 2)

Date 1958	May 15·3	July 4·0	Aug. 23·0	Oct. 12·0	
Nodal period (min.)	105·975	105·365	104·665	103·795	± 0·005
Semi-major axis (n.miles)	4003·1	3987·7	3970·1	3948·0	± 0·2
Eccentricity	0·1114	0·1080	0·1043	0·0995	± 0·0005
Perigee distance (n.miles)	3557	3557	3556	3555	± 2
Angle from apex to perigee	− 32°	− 49°	− 67°	− 85°	± 1°
Inclination to equator	65·19°	65·18°	65·17°	65·16°	± 0·04°

Table 2. ORBITAL DATA FOR *Sputnik* 3 ROCKET (1958 δ 1)

Date 1958	June 20·0	Aug. 4·0	Sept. 18·0	Nov. 2·0	
Nodal period (min.)	104·480	102·580	99·825	95·500	± 0·005
Semi-major axis (n.miles)	3965·4	3917·2	3846·7	3734·8	± 0·2
Eccentricity	0·1032	0·0925	0·0766	0·0506	± 0·0005
Perigee distance (n.miles)	3556	3555	3552	3546	± 2
Angle from apex to perigee	− 45°	− 61°	− 79°	− 97°	± 1°
Inclination to equator	65·17°	65·15°	65·12°	65·08°	± 0·04°

Notes: Apex is point of maximum latitude north. 1 n.mile = 6,080 ft. = 1·853 km. Last column gives estimated root-mean-square errors. No observations of 1958 δ 1 were made from Britain until mid-June.

behaviour: on some favourable transits it has remained obstinately invisible; at other times it has unexpectedly declared itself with flashes of stellar magnitude 1. It has not been necessary to rely entirely on optical observations, however, since the satellite has been transmitting radio signals on 20·005 Mc./sec., and these have, so far, continued with little diminution in strength.

Tables 1 and 2 give information on the orbits of *Sputnik* 3 and its rocket. The orbital inclination, like that[4] of *Sputnik* 2, has been decreasing slightly, probably as a result of lateral aerodynamic forces created by rotation of the atmosphere.

I wish to thank all those who have sent us observations of *Sputnik* 3 and its rocket, and Mrs. D. M. C. Walker, who has analysed the observations.

[1] King-Hele, D. G., and Walker, D. M. C., *Nature*, **182**, 860 (1958).

[2] King-Hele, D. G., and Leslie, D. C. M., *Nature*, **181**, 1761 (1958).

[3] Nonweiler, T. R., *Nature*, **182**, 468 (1958).

[4] Merson, R. H., and King-Hele, D. G., *Nature*, **182**, 640 (1958).

OBITUARIES

Prof. J. A. Gunn, C.B.E.

News of the death on October 21 of J. A. Gunn in his seventy-seventh year will have been received with sorrow by a wide circle of friends and by all pharmacologists who knew him.

Gunn was a true pharmacologist, not a physiologist in disguise; that is to say, his primary interest was in the physiological effects which chemical substances foreign to the animal economy, whether synthetic or of plant origin, produce in animals. This interest led him to ponder deeply upon some of the problems presented by what we now call the structure – action relationships of drugs. In this he was probably influenced by his teacher, Sir Thomas Fraser, who, with his chemical colleague Crum Brown, had made the first systematic attempt to study the structure – action relationships of drugs. It was with Fraser that one of Gunn's earliest papers on "Venoms" was published. At the same time, in the true Scottish tradition, Gunn never forgot the therapeutic possibilities of the substances which he happened to investigate.

Gunn's general point of view was clearly stated in a short review, published in 1935, of his work on the alkaloids of *Peganum harmala*; this paper not only reveals his philosophy as a pharmacologist but is also an excellent example of his lucid and elegant prose style. He was the acknowledged authority on the pharmacology of the harmine alkaloids, on the study of which he was engaged intermittently for twenty-five years. When he began this work the structures of these alkaloids were unknown, but the brilliant investigations of W. H. Perkin, jun., and of Sir Robert Robinson eventually solved the structural problems, and Gunn profited from this work by receiving from Sir Robert Robinson several new and interesting derivatives of the natural alkaloids.

Gunn was the first professor of pharmacology to be appointed in the University of Oxford, and later became the first director of the Nuffield Institute for Medical Research. It is of some interest that he was convinced that every department of pharmacology ought to have a chemist on its staff. For a few years he was fortunate in having an able young chemist, Dr. C. J. Virden, in his Department, and the result of their collaboration was a series of papers on sympathomimetic amines. Gunn was the first to study the pharmacological effects of alkylating the phenolic groups of *para-* and *meta*-hydroxy- and 3 : 4-dihydroxy-phenylalkylamines. Even more interesting was his observation that the replacement of the β-methylene group of phenyl-ethylamine and *-iso*propylamine by an ethylene unit of structure scarcely altered, either qualitatively or quantitatively, the pharmacology of these bases.

Apart from his teaching and research activities. Gunn edited several editions of Cushny's great monograph on pharmacology after the latter author's death; he also wrote an admirable short book on pharmacology from which many generations of medical students have profited; the last edition, in which J. D. P. Graham collaborated, appeared shortly before his death. He was also for many years a member, and later chairman, of the Pharmacopœia Revision Commission, an arduous duty which he took very seriously. British pharmacology owes him a debt of gratitude, not least because the young, but flourishing, British Pharmacological Society owes its origin to his suggestion. Finally, his unselfish nature led him to take a great interest in the careers of young men, and there must be many well-established pharmacologists to-day who owe much to his encouragement and help, and who will remember him with affection and respect.

H. R. Ing

Prof. Stanisław Loria

The death on August 8 of Stanisław Loria is a great loss to Polish physics. He was one of the older generation of physicists, who knew well almost all the great men of the first half of our century. He knew Lorentz and Ehrenfest, and studied with Born and Ladenburg in Breslau. (Usually Prof. Born's first words to me, whenever we met, were: "How is Loria?") He worked in Manchester under Lord Rutherford, and during 1923–26 was a research associate in Pasadena, where he had been invited by Prof. R. A. Millikan. He was well acquainted with the old centres of research. It was a delight to hear him talking about his great teacher Witkowski, about Smoluchowski and Natanson, professors of physics in the old Jagellonian University of Cracow, about Madame Skłodowska Curie, about all the great physicists whom he knew personally and whom the present generation know only from the literature.

Stanisław Loria was born in 1883 in Warsaw. He went to high school and took his university degree in Cracow. In this former Polish capital, then a part of the Austrian Empire, the Polish language was not banned either from the high schools or from the University. There he received his Ph.D. and went for further studies to Wrocław (then Breslau). Göttingen and Berlin, where he spent the years 1907–10. At this time, with Ladenburg, he discovered the phenomenon of anomalous dispersion in hydrogen; the first note on this important effect appeared in *Nature* in 1908.

In 1910 he became a reader (*docent*) in physics in the University of Cracow and in 1919 a professor of physics in the University of Lwów. There he remained until the Second World War—with long intervals devoted to research in laboratories abroad. Even through the War he was in Lwów—up to 1941, when the Germans occupied the town. His last work before the War concerned the problem of diffraction of electrons with energies between 18,000 and 4,500 volts. Unfortunately, it was only partially published, since the apparatus and notes were taken away or destroyed by the Nazis. Prof. Loria had to hide during the German occupation. In free Poland he was a professor in Wrocław and later in Poznań. He died in a London hospital, where he had undergone an operation.

During his life Prof. Loria was very much interested in theoretical physics; he was one of the first physicists who studied Einstein's paper of 1905 and, some years later, wrote in his vivid style a book on relativity theory, the first that appeared on this subject in Poland.

Prof. Loria will be remembered by many Polish physicists. Some of them, including the present writer, owe to his encouragement and help the beginning of their academic careers.

LEOPOLD INFELD

Mr. E. W. Swanton, O.B.E.

MR. ERNEST WILLIAM SWANTON died at Twickenham on October 21 at the age of eighty-eight. After spending his early years as a schoolmaster and private tutor, Swanton was in 1897 appointed the first curator of the Educational Museum at Haslemere, which had been established in 1888 by Mr. (later Sir) Jonathan Hutchinson, a well-known London surgeon. Hutchinson had many novel ideas on the value and arrangement of museums for educational purposes, particularly in the use of living material, the open display of specimens so that they could be handled and in making objective teaching "within the easy ken of all ordinary minds". It was Swanton who was mainly responsible for putting Hutchinson's ideas into practice, 'and so successfully did he build up the educational work that S. F. Markham, in his "Report on the Public Museums of the British Isles", was able to say in 1938: "At Haslemere possibly more educational work of this kind is done than in any comparable museum centre in the country".

In 1898, a few months after his appointment as curator, Swanton began to give regular series of lessons in natural history to children from the local elementary schools, illustrating his lectures by handing around specimens from the Museum collections—an early, if not the earliest, use of museums by organized parties of school-children in this way, and a tradition that has been continued at Haslemere to the present time. In 1899, Swanton organized another feature originated by the founder, which he continued throughout his curatorship: a museum examination for individual local children in which, after several months preparation in the museum galleries in their own time, they were called upon to answer an examination paper covering the whole scope of natural and human history. This was widely hailed as a new contribution to museum teaching techniques.

Swanton had wide antiquarian and natural history interests, but he will be remembered chiefly as a field mycologist. In 1898 he was a foundation member of the British Mycological Society and became its president in 1916. The Society had many notable forays in the Haslemere district with Mr. and Mrs. Swanton as genial hosts. In 1909 he published a useful popular handbook, "Fungi and how to Know Them", which had a second edition in 1922. Among his other publications were "A Pocket Guide to the British Non-Marine Mollusca" (1906), "British Plant Galls" (1912), "A Country Museum" (1947) and, jointly with P. Woods, "Bygone Haslemere" (1914). In the last year of his life he wrote and had privately printed three small books, "A Brief Autobiography", "The Yew Trees of England" and "Memories and Notes".

Swanton was elected an associate of the Linnean Society in 1920, and in 1936 his work at the Museum was recognized by his appointment as M.B.E.; he was advanced to O.B.E. in 1948, the year when he retired. In 1949 he was granted a Civil List pension. His wife, whose help in the work of the Museum he frequently acknowledged, died in 1957.

JOHN CLEGG

NEWS and VIEWS

Royal Medals of the Royal Society

H.M. THE QUEEN has been graciously pleased to approve the recommendations made by the Council of the Royal Society for the award of the two Royal Medals for 1958 as follows: to Prof. H. S. W. Massey, Quain professor of physics at University College in the University of London, for his distinguished contributions to physics, and particularly for his experimental and theoretical studies of collision phenomena in gases; to Prof. A. L. Hodgkin, Royal Society research professor, for his distinguished work on the mechanism of excitation and conduction in nerve and muscle.

Directorship of Dunsink Observatory: Dr. M. A. Ellison

DR. MERVYN A. ELLISON, principal scientific officer at the Royal Observatory, Blackford Hill, Edinburgh, since 1947, has been appointed senior professor of astronomy at the Dublin Institute of Advanced Studies and director of the Dunsink Observatory, situated a few miles from Dublin. Dr. Ellison spent his early years in Ireland, first in the south where he was born in 1909, and later at Armagh Observatory, where his father, Canon W. F. A. Ellison, well known for his astronomical optical work, was director during 1918–36. After graduating at Trinity College, Dublin, in 1932, he taught for some years at Sherborne and successfully pursued his study of solar phenomena in his leisure time, until his appointment at Edinburgh enabled him to devote himself completely to this work. He has published a series of papers on solar flares and their terrestrial effects and on stellar scintillation, which have brought him international recognition, and is the author of a well-known book on "The Sun and Its Influence", which has been translated into several languages, including Russian. He is popular as a lecturer and broadcaster and is president of the Astronomical

Society of Edinburgh. Dr. Ellison is correspondent for solar activity of the British National Committee for the International Geophysical Year and has just been elected to succeed Dr. Y. Öhman, of Sweden, as international reporter for solar activity. After the death of Prof. W. M. H. Greaves and until the appointment of Prof. H. A. Brück as his successor (see *Nature*, 179, 454; 1957), Dr. Ellison served for nearly two years as acting director of the Royal Observatory, Edinburgh. He now succeeds Prof. Brück in the post at Dunsink.

A Commonwealth Overseas Research Council

Lord Home, Secretary of State for Commonwealth Relations, announced at the Commonwealth Trade and Economic Conference in Montreal on September 24 that an Overseas Research Council is to be established to aid Commonwealth countries in scientific research. The United Kingdom Research Councils—Department of Scientific and Industrial Research, Medical Research Council and Agricultural Research Council—are willing, he said, to provide advice and assistance on research matters falling within their respective fields to any Commonwealth country requiring such assistance, wherever this can be done within the funds available. The Overseas Research Council will provide for the co-ordination of this assistance. It will advise Ministers on questions of co-operation in scientific research overseas and will also provide a central point to which Commonwealth Governments and research institutions can refer for advice and information.

The International Atomic Energy Agency : Scientific Advisory Committee

The Board of Governors of the International Atomic Energy Agency has appointed the following to serve on the Agency's Scientific Advisory Committee: Prof. H. J. Bhabha (India) (subject to the concurrence of the Government of India); Sir John Cockcroft (United Kingdom); Prof. V. S. Emelyanov (U.S.S.R.); Prof. B. Goldschmidt (France); Prof. B. Gross (Brazil); Prof. W. B. Lewis (Canada) and Prof. I. I. Rabi (U.S.A.). The function of this Committee is to provide the Board and the Director-General of the Agency with advice on scientific and technical questions arising out of the Agency's programme. The members are appointed in their personal capacity, with the concurrence of their respective governments. Membership of the Committee is identical with that of the Scientific Advisory Committee of the United Nations, and it is expected that this fact will still further strengthen the relationship between the International Atomic Energy Agency and the United Nations.

Nuclear Safety Advisory Committee

In moving the second reading of the Nuclear Installations (Licensing and Insurance) Bill in the House of Lords on November 13, the Minister of Power, Lord Mills, said that he and the Secretary of State for Scotland had decided to appoint a Nuclear Safety Advisory Committee composed of experts of the highest standing. They regarded such a Committee as necessary in view of the rapid strides which nuclear science and engineering were making and the consequent continuous evolution of the attendant problems of safety. In making appointments to the Committee, they intended to consult, *inter alia*, the Atomic Energy Authority, manufacturers of nuclear plant, the insurers, and the owners and operators of major nuclear installations. They had decided to establish this Committee administratively rather than by statute because developments in the industry were hard to foresee and might eventually necessitate changes in the constitution of the Committee or its terms of reference and such changes would thereby be more easily made. Referring to the exemption of the Atomic Energy Authority from licensing under the Bill, Lord Mills explained that the Authority's work was mainly experimental. To include it, apart from involving delays, would require a much larger inspectorate and also inspectors as expert in advanced research as the Authority's own scientists. Government departments would not normally be subject to licensing, but it was intended that they should follow the safety principles evolved between the Minister, the Atomic Energy Authority and the Nuclear Safety Committee and they would be under the same third-party liability as the Authority. Replying to questions in the debate, Lord Mills added that the Bill did not cover the question of hospitals or the manufacture of pharmaceuticals, nor was it intended to cover ordinary university research or similar activities. If and when these activities required cover, fresh measures would be laid before Parliament.

Moon Rocket Tracking

A 108-mc./s. interferometer with a base line of 80 wave-lengths was used by the Royal Aircraft Establishment of the Ministry of Supply on November 8 to track the third American Moon rocket. A satisfactory record was obtained during 07.47–08.01 G.M.T., that is, for the time the rocket was above the horizon as seen from Great Britain. When the complete analysis is available the bearing of the rocket from Lasham, Hampshire, where the interferometer is located, will be known at every instant during this period with an accuracy of about 1 sec. of arc—an accuracy in position of approximately 10 miles at 4,000 miles range. Since the launching point is known, it should be possible to determine the complete orbit of the rocket, and by extrapolation to make a very fair estimate of the area where any surviving pieces may be. It is interesting to note that observers at Lasham realized at 07.55 that the missile had gone astray, since the type of record obtained was similar in character to those for the American Earth satellites. It is a feature of this equipment that a rapid assessment of the missile projectory is possible. The accuracy of bearing realizable with a fixed aerial equipment of this type is some hundred times greater than is possible with types of steerable aerials.

Central Agency for Carbon-14 Determination

During recent years, the study of primary production in the sea has been followed by radioactive tracer methods using carbon-14, a technique first employed by Nielsen. The method is very useful in that the field-work does not presuppose any expert knowledge of radiochemistry. On the other hand, manufacture of the necessary ampoules of sodium bicarbonate solution labelled with carbon-14, and the measurements of the radioactivity of the resulting filters, do require the facilities of a well-equipped radiochemical laboratory. In order to make such facilities available to the smaller marine laboratories, the recommendations adopted at the 1957 Bergen symposium on "Measurement of Primary Production in the Sea" have now been implemented and a central agency has been set up at Charlottenlund Slot, Denmark. This has been made possible by the provision of funds by Unesco in January 1958, and of a room in its residence at Charlottenlund Castle by the Danish Institute for Fisheries and Marine Research. Prof. E. Steemann Nielsen, adviser in plankton research for that Institute, has been appointed honorary supervisor, and the daily work will be directed by Mr. Vagn Hanson, also of the same Institute. The facilities of the Agency are available to all scientific institutions in the world, and as well as providing the service mentioned above, the Agency also supplies the necessary ancillary equipment for use in the field. Full details can be obtained from Prof. E. Steemann Nielsen, The International Agency for Carbon-14 Determination, Charlottenlund Slot, Charlottenlund, Denmark.

British Information Services

QUESTIONS in the House of Commons on November 3 regarding the improvement of British information services overseas brought a reply from the Chancellor of the Duchy of Lancaster, Dr. Charles Hill. He said that as a result of his visit in September to information posts in India, Pakistan, Aden, British Somaliland, Kenya, Ethiopia and Somalia, he had formed the conclusion that we should intensify our effort, adapt it to new circumstances and increase the resources available. He referred particularly to the need to counter hostile radio propaganda, to increase the flow of British books, and to expand the programme of teaching English. The Government has approved in principle a substantial strengthening of our information effort, and plans are now being worked out. He hoped to report in detail in a few weeks time, and in reply to a further question promised to consider the issue of a White Paper showing the progress made in implementing earlier proposals. That relating to the distribution of English books overseas was particularly welcomed.

High-Altitude Research

IN reply to questions in the House of Commons regarding Earth satellites on November 3, the Minister of Supply, Mr. Aubrey Jones, said that the *Black Knight* is a test vehicle for high-altitude research, and a programme of further firings is planned. The opportunity for space research arises from certain techniques being developed for the defence programme. His officials are in constant touch with the Office of the Lord President of the Council and numerous scientific authorities on the scientific value to be obtained from British participation in space research, including research investigations by satellites. The scientific value and not finance is the real question at issue, and the possibility of co-operation with other countries is also taken into account.

Salaries of Teachers in Technical Institutions

ONE of the main recommendations of the committee which, under the chairmanship of Sir Willis Jackson, met to consider the supply and training of teachers for technical institutions was the need to recruit people of good calibre from industry. Perhaps the greatest deterrent is the disparity between the salaries paid to technical college teachers and their colleagues in industry. This matter has been considered recently by the Association of Teachers in Technical Institutions, leading to a memorandum which has been submitted to the Teachers' Panels of the Burnham Main Committee and the Burnham Technical Committee.

The main recommendations include the abolition of all grade *A* assistant posts in technical institutions and that all teachers holding these positions should become assistants grade *B*; this grade should be renamed 'assistant lecturer'. The remaining grades of teacher should remain substantially as at present except that the grade of 'reader' should be renamed 'principal lecturer' and be available for research, advanced teaching or administrative responsibility in all colleges doing work of university standard. A new grade of deputy head of department should be established for large departments. For all these grades there should be increases in salary in appropriate relation to the increases given to assistant lecturers. The Association also proposes the establishment of national scales of salaries for part-time teachers, based on the principle that the cost of carrying a given teaching load should be the same whether the work is done by part-time or full-time teachers.

Unesco Programme for Arid Lands

UNESCO Information Manual 3 contains a concise, clear and readable account of the Unesco Programme for Arid Lands (pp. 31. Paris: Unesco; London: H.M. Stationery Office, 1958). Commencing with a statement of the nature and extent of the problem presented by the arid zones, representing about one-third of the Earth's total land surface of 33,000 million acres, compared with the 3,300 million acres under cultivation, the pamphlet briefly describes the way in which the problem has been attacked by Unesco during the past ten years, its search for facts, the steps taken to inform the scientific world, through, for example, a Directory of Institutions engaged in Arid Land Research and a Guide Book to Research Data for Arid Land Development, and the way in which the attack on the desert has now become a major project of Unesco. Steps taken to develop water resources are indicated, including the use of artificial means for provoking rainfall, demineralization of salt water, studies in plant ecology of the arid zone, and the harnessing of sun and wind, and the pilot project to study the social adjustment of nomadic and semi-nomadic groups to settled existence. An outline is given in the 1957–58 programme. The pamphlet contains a bibliography and a select list of visual aids on a subject in which, besides the International Council of Scientific Unions and several of the individual unions, the Scientific Council for Africa South of the Sahara, the World Power Conference and a number of other international bodies are already interested.

The Analyst

THE earliest ten volumes of *The Analyst*, for the years 1876–85, have been re-published in facsimile form by W. Heffer and Sons, Ltd., of Cambridge, who are the publishers of the journal on behalf of the Society of Analytical Chemistry. These volumes cover the early years of the operation of the Sale of Food and Drugs Act, 1875, and are of considerable historical importance. During these ten years chemical analysis passed from the sphere of the dilettante chemical investigator to that of an exact science, capable of legal argument and applicable on an industrial scale. The analysis of water was systematized, and the beginnings of biological examination are described in many of the papers. The Society whose journal this is, although then named 'The Society of Public Analysts', has catered from its inception for all classes of analyst; for example, Vol. 1 contains papers on the analysis of coal and of plating and gilding solutions, as well as much work on various foods. Each volume is available separately from any bookseller or direct from the publishers at 6 guineas, bound in cloth boards in the style of the original. Publication in America is through the Johnson Reprint Corporation.

The Wellcome Museum of Medical Science

SINCE it was opened by the Wellcome Foundation in 1914, the Wellcome Museum of Medical Science in Euston Road, London, has provided a unique display of photographs, specimens and extracts from medical literature, which give, in study units housed in comfortable and attractive bays screened off from the rest of the Museum, comprehensive information about each of the diseases dealt with (see "The Wellcome Museum of Medical Science". Pp. 40. London: The Wellcome Foundation, Ltd., 1958). Some 10,000 doctors, nurses, medical missionaries and students visit the Museum each year from all parts of the world. Originally the Museum was devoted largely to tropical diseases, but nowadays it covers a much wider field. Recently reorganized, it now reflects the changes in emphasis on certain diseases which have resulted from the remarkable advances in control and treatment that have been made in recent years. Thus, the thirty-two panels formerly given to syphilis have now been reduced to four, and the seven panels given earlier to plague have been reduced to three. Cholera also is no longer feared as it used to be. Malaria, however, still occupies forty-two panels, though if the schemes for its control and eradication continue to succeed as they have done during the past five years, much less space will be needed to cover this disease, which has for long been the greatest single cause of illness and death in the world. Tuberculosis, on the other hand, is likely to be given more space to illustrate its importance in the tropics. A pleasing feature of the Museum's activities is the use that is made of it by boys' and girls' schools, to which the Museum lends suitable selections of material for the stimulation of interest in biology. It also lends or gives exhibits to medical schools throughout the Commonwealth. Last year a section of the Museum was shown in Durban, South Africa, and another section, devoted to trypanosomiasis in Africa and South America, was shown at the sixth International Congress on Tropical Medicine and Malaria at Lisbon.

Systematics of Parrot-fishes

THE brightly coloured parrot-fishes are ubiquitous denizens of coral reefs throughout the tropics. For feeding on coral the dentition has been greatly modified, with fusion of the teeth in the front of the jaws into a pair of dental plates forming the 'parrot's beak' from which these fish get their name. The pharyngeal musculature is highly developed and operates a mill formed of grinding teeth on the pharyngeal bones. Many of the species have a large swelling on the forehead which adds to their bizarre appearance. In the past, the systematic description of this group has been highly confused and more than 350 species have been named and described. In a recent publication (U.S. National Museum, Bulletin 214: Review of the Parrotfishes, Family Scaridae, by L. P. Schultz. Pp. v+143+27 plates. Washington, D.C.: Government Printing Office, 1958. 75 cents), the curator of fishes of the United States National Museum has done much to unravel the confused systematics of the parrot-fishes. He claims that only eighty species can be regarded as valid. Many of the large number described, he points out, have been erected into so-called species on the basis of colour patterns which vary not only between individuals but between different stages in the life-history of one individual, while there is also a sexual dichromatism. His review of the Scaridae at last places this family in some sort of perspective and demonstrates their relationship with the labrid fishes. There are excellent keys to genera and species.

Dormancy in *Viburnum* Seeds

IN an investigation of dormancy in the seeds of *Viburnum trilobum*, R. H. Knowles and S. Zalik (*Canadian J. Bot.*, 36, 561; 1958) have observed this phenomenon in seedlings as well as in seeds. When seeds were maintained at 20° C. under suitable conditions for germination, there was slow growth in the radicle and hypocotyl in some seeds, while others showed no response. They have found that this kind of dormancy is associated with the presence of a water-soluble inhibitor in the endocarp and with the need for an appropriate (inductive) temperature treatment prior to exposure to a constant 20° C.; they also found that dormancy in the epicotyl, namely, failure of shoot growth in the young seedling, could be overcome by removing the cotyledons.

Tropical Karst

LANDFORMS developed in regions of massive limestone or dolomite where erosion is principally by solution of the rock rather than mechanical corrasion have long been known as 'karst' from the area in Yugoslavia where they were first investigated. The karstlands of temperate latitudes have received considerable attention, but their occurrence in tropical areas has been less closely studied. In an article in the *Geographical Journal* (124, part 2, 184; June 1958) Dr. Marjorie Sweeting gives an admirably lucid account of its distribution and characteristics in Jamaica. She shows that even in an area of pure, free-draining limestone an annual rainfall of 100 in. or more is sufficient to maintain a heavy forest cover and that water passing through this cover is so highly charged with organic carbon dioxide that the solution rates may be 400 per cent greater than in cooler climates. The most characteristic land-form produced under these conditions is 'cockpit karst', in which the entire surface is covered by conical depressions, here 300–400 ft. deep, separated by cone-like hills. There are no watercourses on the surface. Where the crystalline white limestone passes into other formations and free vertical drainage is checked, solution and sapping takes place along the base and sides of the cockpits and the mechanical effect of flood water in undercutting and steepening the sides is considerable, and 'tower karst' develops. Dr. Sweeting indicates that in areas of more marly limestone and lower rainfall dolines and poljes, already well known from European examples, develop. She gives some attention also to associated caves and underground river systems.

Mond Nickel Fellowships

THE Mond Nickel Fellowships Committee recently announced the award of fellowships for 1958 to the following: Mr. G. H. Longworth (Lancashire Steel Manufacturing Co., Ltd.) to study the manufacture of plain carbon and alloy steels for rod and wire products in the United Kingdom, on the Continent, and in the United States; Mr. J. C. Morrison (Carron Company) to study melting, moulding and heat treatment of alloy cast irons, quality control of metal and sand plants in modern foundries, and new developments in related metallurgical processes; Mr. T. Tait (Colvilles Limited) to study the technical and economic factors involved in the use of oxygen in steel industries in the United Kingdom, on the Continent, and in the United States and Canada.

The Mond Nickel Fellowships Committee is offering one-year fellowships valued at £900–£1,200 for 1959, to graduates of British nationality to enable them to obtain wider experience and additional training in industrial establishments, in Britain or abroad, to make them more suitable for future employment in senior technical and administrative positions in British metallurgical industries. Applicants will be required to state details of the programme they wish to carry out. Particulars and forms of application are available from the Secretary, Mond Nickel Fellowships Committee, 4, Grosvenor Gardens, London, S.W.1.

Mechanization of Thought Processes

A symposium on "The Mechanization of Thought Processes" is being held at the National Physical Laboratory, Teddington, during November 24–27. More than two hundred delegates will be attending. After opening sessions on general principles, succeeding sessions will be devoted to automatic programming, language translation, speech recognition, learning in machines, and implications for biology and for industry. Further information can be obtained from the Chief Information Officer, Department of Scientific and Industrial Research, Charles House, 5–11 Regent Street, London, S.W.1.

United Nations Conference on Peaceful Uses of Atomic Energy: Proceedings

The United Nations have announced that the pre-publication period for the Proceedings of the Second U.N. International Conference on the Peaceful Uses of Atomic Energy, during which complete sets may be ordered at a special price, has been extended to January 31, 1959. The action was taken to facilitate the budgetary arrangements of institutions unable to purchase the complete set of volumes from their 1958 budgets. Until January 31, the thirty-three volumes of the English edition may be ordered for 435 American dollars, £155 sterling, or 1,860 Swiss francs. The special pre-publication price for the complete set represents a saving of some 70 dollars as compared with the regular price of the set. For the French and Spanish editions, each of which is expected to include approximately fifteen volumes, the special pre-publication price will be 190 U.S. dollars, £68 sterling, or 815 Swiss francs. If the number of volumes is less than fifteen, proportionate refunds will be made to subscribers who have ordered a full set. Further information can be obtained from the United Nations, Sales and Circulation (Atomic Energy), United Nations, New York.

The de Havilland Aircraft Co., Ltd.: Appointments

Mr. R. G. McCoy has been appointed general manager of the de Havilland Aircraft Co., Ltd., with effect from December 1. He joined the company in May 1953 as deputy service manager, becoming manager in April 1954, and was responsible for the Service Department until July 1958, as well as acting as assistant to the managing director from January 1956. Mr. D. R. Newman has been appointed chief aerodynamicist of the company with effect from December 1. Mr. M. Herrod-Hempsall remains responsible for administration in the Aerodynamics and allied Departments. Mr. Newman joined the de Havilland Aeronautical Technical School in April 1936 and has been in the Aerodynamics Department since May 1938.

Announcements

Prof. E. E. Zepler, professor of electronics in the University of Southampton, has been elected president of the British Institution of Radio Engineers for 1958–59.

Sir Walter Drummond has been appointed chairman of the Farm Buildings Research Committee of the Agricultural Research Council, in succession to Lord Rothschild. The Farm Buildings Research Committee has been set up by the Council to co-ordinate the different research activities concerned with farm buildings and to advise on their further development.

The 125th meeting of the American Association for the Advancement of Science will be held in Washington, D.C., during December 26–31, with headquarters in the Sheraton-Park Hotel. In addition to the eighteen sections of the Association, about ninety-two affiliated and associated societies will participate. The presidential address, on "Fifty Years of Medical Genetics", will be delivered by Dr. Laurence H. Snyder, president of the University of Hawaii, and retiring president of the Association. Further information can be obtained from Sidney S. Nagus, Medical College of Virginia, Richmond, Virginia.

A group of experts from Australia, Germany, Iran, Portugal, South Africa, United Kingdom and the United States is meeting, under the auspices of the Food and Agriculture Organization and the Office International des Epizooties, to consider problems of ticks and tick-borne diseases. The meetings are being held during November 24–29, at the Royal College of Veterinary Surgeons in London. Further particulars can be obtained from the Registrar of the College, 9 and 10 Red Lion Square, London, W.C.1.

The 129th course of six Christmas lectures "adapted to a juvenile auditory" will discuss the International Geophysical Year, and is to be delivered at the Royal Institution on December 30, 1958, and January 1, 3, 6, 8 and 10, 1959, at 3 p.m. The lectures are as follows: "The Ionosphere and the International Geophysical Year", by J. A. Ratcliffe; "Geomagnetism", by J. M. Stagg; "Exploration of the Upper Atmosphere", by Dr. R. L. F. Boyd; "Meteorology", by Sir Graham Sutton; "Oceanography in the International Geophysical Year", by Dr. G. E. R. Deacon. Applications for tickets (juveniles, aged 10–17, £1; adult non-members, £2) should be addressed to the Royal Institution, 21 Albemarle Street, London, W.1.

A symposium on "Experimental Approaches to the Problems of Growth and Form in Plants" is being held in the rooms of the Linnean Society of London during December 19–20. This is being arranged by the Experimental Plant Morphology Group of the Society and the Symposium is open to visitors. Further information can be obtained from the Secretaries, Linnean Society, Burlington House, Piccadilly, London, W.1.

THE WORLD REFERENCE LABORATORY FOR FOOT-AND-MOUTH DISEASE

THE control of diseases of livestock is an important feature in the general economy of most countries in improving animal production and in fostering international trade in livestock and animal products. Foot-and-mouth disease is one of the most troublesome of the infectious diseases of livestock, and increasing attention is now being given on an international basis to its control and eradication.

It is gratifying to learn in this connexion that one of the recent steps taken, following negotiations between the Food and Agriculture Organization of the United Nations and the British Government, has been the establishment of a World Reference Laboratory for Foot-and-Mouth Disease at the Research Institute (Animal Virus Diseases), Pirbright, Surrey, which functions administratively under the ægis of the Agricultural Research Council.

It is particularly appropriate that the Pirbright Institute should have been asked to accept this responsibility because of its experience in the examination of virus material from all over the world during the past ten years and because it has all the necessary facilities for the full examination of suspect material.

The Institute reported recently the results of the examination and immunological classification of 2,200 virus samples from outbreaks in countries in Europe, Africa, Asia and the Americas. This must be considered only as a useful first contribution to a very big epizootiological problem as there are many areas which have not yet been covered. A satisfactory epizootiological world picture cannot be produced until a reasonably large number of samples have been examined from outbreaks in as many countries as possible. The Food and Agriculture Organization is seeking the co-operation of governments so that the surveys carried out for a number of countries will be continued and extended. It is hoped that one of the immediate results of this will be the continued collection and dispatch to the World Reference Laboratory, now established, of suitable field samples from outbreaks of the disease in countries all over the world.

The virus of foot-and-mouth disease, unlike those of yellow fever and rinderpest, is characterized by the lack of antigenic homogeneity. There are at present seven main immunological types of the virus (compared with three in poliomyelitis, three in influenza, three in equine encephalomyelitis and two in vesicular stomatitis). The well-known types *O*, *A*, and *C* (1922–26) have been found in Europe, the Americas, Asia and Africa, and the work of the Pirbright Institute has brought to light four other types, three (*S.A.T.*1, *S.A.T.*2 and *S.A.T.*3) at present known only in Africa but one as far north as Egypt, and the fourth, *ASIA* 1, only in Asia but as far west as Iran and Israel. It is possible that other types of the virus may be discovered as the result of more extended surveys. There are, in addition, strains of the virus within each main immunological group which differ sufficiently in antigenic constitution to classify them as variants or sub-types. Control programmes in many parts of the world include vaccination, and an essential to make these effective is accurate information on types and strain differences, so that appropriate vaccines can be used.

It is universally recognized that there is considerable advantage in having a central laboratory which is in a position to collect information on the distribution of virus types responsible for outbreaks, sporadic, enzootic and epizootic, and to complete surveys by collecting essential information on the character of outbreaks, the number and species of animals involved, the possible origin of outbreaks and other relevant details. The resulting epizootiological picture would be of much value in organizing methods of control and eradication and in assisting countries to estimate risks associated with trade. Reports of the world position will be issued through the Food and Agriculture Organization from time to time.

The functions of the World Reference Laboratory will include also the examination and classification of virus types and sub-types, the ultimate establishment of a collection of all types and confirmed sub-types and their corresponding antisera. It is not intended that the World Reference Laboratory should undertake the routine examination of virus material from European countries or the Americas, since there are already facilities for this purpose. The World Reference Laboratory will, however, give all possible assistance if specially requested to do so and will be assisting with the sub-type classification problem and be responsible for the examination and identification of strains of virus suspected to be other than types *O*, *A*, and *C*.

THE NATIONAL VEGETABLE RESEARCH STATION

REPORT FOR 1956–57

THE eighth annual report* of the National Vegetable Research Station, recently published, provides a summary of the progress made by the eight sections of the Station. Some of our common vegetables are receiving the attention of the plant breeders, and further advance has been made in selecting a non-bolting type of red beet having single-seeded fruit. The production of onion and brussels sprout hybrids and a winter-hardy culinary pea is also being pursued. A report by L. E. Watts and R. A. T. George on a two-year investigation of the classification and performance of radishes involved the testing of 114 varieties made up of approximately equal numbers from British and foreign sources. An appendix to this report gives a classification and grouping of radish varieties. The authors conclude that there is no urgent need for a breeding programme for this vegetable as commercial varieties of satisfactory quality are already available.

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* British Society for the Promotion of Vegetable Research. Eighth Annual Report, 1957 (October 1956–September 1957). Pp. viii+67. (Wellesbourne, Warwick: British Society for the Promotion of Vegetable Research, 1958.)

The Chemistry Section has continued the analysis of the long-term field experiments and investigated the effect of different manurial treatments on soil structure. An examination of the biochemical factors affecting the germination of seeds was commenced. The chemical changes occurring in the root of red beet when clamped and during flowering are being studied. The nature of the competition between weeds and vegetables is one of the problems being investigated in the Physiology Section, which is also concerned with growth studies of vegetable crops with the object of finding how various manurial treatments affect the growth and yield of crops. The influence of various treatments on the flowering of vegetables is being studied. In the Irrigation Section emphasis is shifting from treatments applied throughout the life of the plant to treatments applied at certain stages of growth. In general, it has been found that abundant water supply increases the quality of foliage of most vegetable plants and also increases the yield of saleable material. It seems clear that each crop will have to be considered on its merits regarding irrigation requirements. Work has continued on the development of an irrigation gauge.

The Entomology Section has made further studies on beetle predators of the cabbage root fly. It was confirmed that low rates of soil insecticides broadcast on the soil resulted in an increased infestation of cabbage root fly. Further work is being carried out on the soil application of soil insecticides for control of carrot fly on carrots and parsnips. An outstanding result obtained by the Pathology Section was the successful use of zinc frit for control of the crook root disease of watercress, resulting in increased yield. Weed investigations include observations on the effect of vegetable cropping on the weed population of original corn land. Various herbicide trials are also in progress. The Statistics Section has, besides handling routine inquiries from other Sections, investigated fitting of growth curves and has worked out designs for the assay of virus preparations on *Nicotiana glutinosa* and *Phaseolus vulgaris*. Apart from the usual weather observations, the use of a special rain-gauge with its rim only 1 in. above ground was continued. Rainfall collected in this gauge was 5 per cent greater than that collected in the standard gauge, thus confirming previous observations at this Station. By using gauges at different heights above the ground it was found that the amount of rain collected was a function of the height of the gauge above the ground and the run of the wind.

METALS AND ALLOYS ABOVE 1,200° C.

A SYMPOSIUM on "The Study of Metals and Alloys above 1,200° C." was held in the Department of Metallurgy of the University of Oxford on September 17 and 18; the subjects discussed at the four sessions are outlined below. Prof. W. Hume-Rothery welcomed the visitors to the symposium in an introductory address, and emphasized the increasing importance of the topic under discussion. He urged that metallurgists should look ahead five or ten years: design engineers were always limited by the high-temperature alloys available to them.

Metals and Alloys of High Melting-point

The first session was devoted to a study of the properties of some refractory metals and alloys—the platinum metals, tungsten alloys, molybdenum, and titanium–carbon alloys. Prof. E. Raub (Forschungsinstitut für Edelmetalle und Metallchemie) emphasized the relatively high reactivity with gases and refractory materials possessed by the platinum metals and alloys at high temperatures. Subsequent discussion centred on whether oxygen diffusion can take place through platinum, and it was concluded that it did not diffuse through metal of very high purity, although internal oxidation, for example, has been observed in dilute alloys. Raub also considered the reaction of the platinum metals with refractory materials, and described methods of melting and annealing these alloys, pointing out the main difficulties encountered by metallurgists studying their behaviour.

R. Kieffer, K. Sedlatschek and H. Braun (Metallwork Plansee, Reutte-Tirol) presented a paper on sintered high-melting tungsten alloys, outlining various methods for preparing the metal and for the production of cold ductile alloys. The alloy systems described were tungsten–molybdenum, tungsten–niobium and tungsten–tantalum; in the last case the following properties of sintered tungsten alloys with 0–100 per cent tantalum were outlined: density, hardness, elastic moduli, electrical resistivity, ease of hydrogenation, oxidation behaviour and corrosion resistance in acids and alkalis.

A. R. Moss (Armaments Research and Development Establishment, Woolwich) considered the thermal, mechanical and physical factors affecting the grain structure of arc-melted molybdenum, and finally R. L. Bickerdike and G. Hughes (Royal Aircraft Establishment, Farnborough) described a vacuum-quenching furnace which had been used to examine the titanium-rich end of the titanium–carbon system between 1,558° C. and 1,763° C.

High-temperature Techniques

The session opened with papers on zone melting by G. A. Geach and F. O. Jones (Associated Electrical Industries) and J. A. Belk (Woolwich). The first paper described an arc-melting technique and also a floating-zone method, using electron-bombardment heating to melt a narrow zone of the specimen, applied to refractory metals including rhenium and tungsten. Belk gave further details of the latter method, applied to the removal of carbon from vacuum-cast molybdenum. The mechanical properties of the purified material in single crystal and polycrystalline form were summarized.

Arc-melting processes were outlined in papers by A. R. Moss (Woolwich), J. R. Murray and G. K. Williamson (Atomic Energy Research Establishment, Harwell) and F. O. Jones, A. G. Knapton and J. Saville (Associated Electrical Industries). Moss discussed the basic principles of the various vacuum-arc and inert-gas arc-melting processes, followed by a consideration of the electrical and mechanical equipment in common use. Murray and Williamson reviewed the application of arc-melting, and other melting techniques used in alloy investigations at temperatures above 1,200° C. at Harwell, and further descriptions of arc-furnace techniques were given by Jones, Knapton and Savill, who also considered electron bombardment heating as supplementary to arc-furnace techniques. Finally, a special molybdenum-wound cooling curve furnace was described by W. Oldfield (British Cast Iron Research Association), in which the element completely surrounds the specimen container.

Physical Properties and Equilibria at High Temperatures

The first two papers were concerned with crystal structure. A. J. Martin and A. Moore (Atomic Weapons Research Establishment, Aldermaston) discussed the structure of beryllium at temperatures between −185° C. and 1,290° C. No evidence was found to support other workers' claims of allotropy in the range 400–800° C. They showed, however, that the lattice is hexagonal up to about 1,250° C., above which the structure is body-centred cubic, and the authors discussed the possibilities of retaining this structure form at temperatures below 1,250° C.

The Metallurgy Department, Royal Aircraft Establishment, Farnborough, then presented a paper on the structures of graphites deposited from hydrocarbon gases at various temperatures and pressures. The effect of changes in deposition temperature on the density and X-ray diffraction pattern was shown. 'Flecks', not unlike deformation bands, are produced on the surface of these graphites when they are deformed.

The remaining papers of the session were concerned with high-temperature equilibria; C. W. Haworth (University of Oxford) described tungsten-resistor furnaces in which specimens weighing 1–5 gm. can be annealed *in vacuo* or in argon up to 2,700° C. and then quenched. The apparatus has been used in work on molybdenum base alloys. A. Hellawell (University of Oxford) directed attention to the face-centred cubic/body-centred cubic transition found in the metals of the first three transition series, and described apparatus which has been used in the thermal analysis of these phase transitions. The influence of various solute elements upon the transition in manganese and iron was shown to be related to the structures of the elements concerned.

The last paper of the session, by P. Gross, D. L. Levi and G. Wilson (Fulmer Research Institute), discussed methods for determining the thermodynamic activities of alloy constituents at high temperatures. Two methods for measuring vapour or reaction pressures have been used—an effusion method (restricted to systems in which the pressure of any constituent does not exceed about 0·1 mm. mercury) applied to alloys containing iron and aluminium at 1,300° C., and also a capillary vessel method where the reaction pressures are beyond the range of the effusion method.

Mechanical Properties at High Temperatures

In a paper on high-temperature mechanical working of molybdenum, E. W. Ward (Woolwich) discussed the factors affecting the breakdown of the arc-cast structure. The microstructures produced by rolling and extruding at temperatures up to 1,800° C. showed that true hot working had been achieved.

Two papers concerned with the measurement of mechanical properties followed. L. M. T. Hopkins (National Physical Laboratory) described determinations of the creep properties of ceramics and high melting-point metals in air and *in vacuo*, respectively. B. L. Mordike and L. M. Fitzgerald (University of Cambridge) are investigating the properties of the refractory metals tantalum, tungsten, niobium and molybdenum, and the carbides of tantalum, tungsten, niobium, titanium, zirconium, vanadium and boron up to their melting points, which lie in the range 2,500–3,500° C. Apparatus to measure the tensile strength of metals, friction of carbides and hardness determinations of metals and carbides were described.

D. M. Gilbey (Farnborough) presented an extension of the simple theory of the thermal stresses in flat plates, so that variations with temperature and stress of the thermal and elastic properties of the material can be taken into account. The stresses calculated by this method for a manufactured graphite were compared with those obtained from the simple theory using constant 'effective values' of the 'constants'.

The session concluded with a paper by D. T. Livey (Harwell) on the high-temperature stability of oxides and sulphides. The behaviour of the stable refractory oxides *in vacuo*, oxidizing and reducing atmospheres was considered; the refractory sulphides are thermodynamically less stable, in general, than the oxides, although the sulphides of cerium and thorium have been used for reactive metals. Kinetic factors, rather than thermodynamic stability, control the degree of reaction between metals and oxides or sulphides, at least for the more reactive metals.

During the symposium, an exhibition of apparatus, refractories, etc., was held at the University Department of Metallurgy. Exhibits were lent by a number of industrial firms, research establishments, and university departments.

J. W. MARTIN

INVASIVENESS AND SURFACE PROPERTIES OF CANCER CELLS

An informal symposium on the surface properties of cells and their possible bearing on the invasive movements of cancer cells was held at the Chester Beatty Research Institute on July 4. The chair at the morning session was taken by Prof. A. Haddow and in later sessions by Dr. B. Sylvén (Stockholm) and Prof. G. Klein (Stockholm).

Prof. Haddow pointed out in his introductory remarks that the bearing of the surface properties of cancer cells on their invasiveness has received little attention, apart from the microhistological studies of Dr. Coman and his collaborators in the United States. But interest in the surface properties of cancer cells has developed during the past few years, stimulated largely by Dr. M. Abercrombie's studies of cell movements in tissue culture. It had, therefore, been decided to bring together some of those specialists most directly concerned with this largely unexplored field.

Dr. M. Abercrombie (London) then described the conditions for the invasion of normal cell explants by tumour cells in culture. Whether or not invasion occurs appears to be determined largely by the effect that contact between interacting cells has on their locomotion. In the cell species so far studied, it is found that sarcoma cells invade explants of normal fibroblasts, whereas populations of normal fibroblasts do not invade each other. Sarcoma cells invade because they treat normal fibroblasts like any other substrate for their locomotion. They adhere to and are guided by oriented structure in any substrate, whether cellular or non-cellular.

To a normal fibroblast other fibroblasts are not simply equivalent to substrates ; they are obstacles to locomotion. Contact with them results in an adhesion, immobilizing the small-scale membrane activity in its neighbourhood and stopping the cell from advancing in the direction of the adhesion. This is contact inhibition (Abercrombie and Heaysman, 1954 ; Abercrombie and Ambrose, 1958). Its nature is unknown, but it is possible to reduce it by changing the composition of the liquid phase of the culture (Curtis, unpublished). The behaviour of fibroblasts towards sarcoma cells appears to be different from the behaviour of sarcoma cells to fibroblasts. There is some inhibition of fibroblast locomotion by sarcoma cells which seems to be effected through a diffusible agent. A small number of experiments have shown that explants of sarcoma cells of different type invade each other.

Is it possible that the loss of contact inhibition and increased activity of the cell membrane is related to the uncontrolled growth of tumours ? Prof. M. Swann (Edinburgh) described some interesting observations on the growth of soil amœbæ, which suggest that in this organism growth is affected by contacts. Mr. D. Harrison, working in Edinburgh, had studied the growth of *Hartmanella* in sterile culture. Growth in this case appears to be limited by mutual contact, which is reflected, after an early exponential phase, in the fact that the growth-curve of an amœba culture becomes linear over a considerable range, before it finally flattens out. A variety of experiments have shown that this is not due to environmental conditions, but solely to cell contacts. The linear phase can be abolished by treatment with antisera, when the growth-curve remains exponential for much longer. It seems possible that the contact effect is a direct mechanical inhibition of vacuole intake. Treatment with antiserum presumably prevents close contact and so abolishes the inhibition of growth by contact. Although experimentally difficult to carry out, a similar investigation using mammalian cells would be of great interest.

Various physico-chemical techniques are now being used for a direct study of the nature of the cell surface ; they were described by Dr. G. C. Easty (London). He first referred to earlier work on the erythrocyte membrane, which indicates that it is of a lipoprotein nature. A direct examination of the membrane is more difficult with mammalian cells, but it is known that tumour cells carry a net negative electrical surface charge which is almost twice that of the homologous normal cells (Ambrose, James and Lowick). Further information has been obtained by G. C. Easty, D. M. Easty and E. J. Ambrose, who have studied the effect of enzymes upon the adhesiveness of tumour cells to glass surfaces by a new centrifugation technique. The most effective enzymes for breaking contacts between ascites tumour cells and glass have proved to be lipase, phosphatases and elastase. These enzymes are thought to react with lipid, phosphate groups and protein, suggesting that the tumour cell surface is also composed of lipoprotein. The increased negative electrical charge could, therefore, be due to an excess of phosphate groups of phospholipid.

A more general biological approach to the changes in cell populations arising during transformation from normal to tumour tissue was then considered by Prof. and Mrs. G. Klein (Stockholm). They have obtained most interesting evidence for a progressive transformation in sublines derived by selective transplantation from a single tumour (*MCIM* sarcoma). The M_{SS} sublines are solid tumours which do not readily produce ascites cells when transferred to the peritoneum, and only produce metastases very late in the growth of the tumour. The M_{AS} sublines readily form ascites tumours and produce early metastases. These stepwise changes in biological characteristics can be correlated quite well with surface changes, the more anaplastic cell types (M_{AS}) showing a higher electrical charge than the M_{SS} types (Purdom, Klein and Ambrose).

Prof. E. Wolff (France) described a valuable technique using organ culture with mixed tissues and mixed species for the study of invasive movements. Real organ chimeras can be produced from associated duck and mouse testes in which testicular tubules may be formed from cells of the mixed species. In fragments of chick and mouse lung also, the mouse bronchial tubes grow and branch in pure chick connective tissue. Sometimes the two epithelia join and form a common canal. These results indicate that homologous tissues of the two species show more mutual affinities than heterologous tissues of the same species. Several sarcomas have been examined under the same conditions by Prof. Wolff. Fusion between embryo and tumour first occurs. All tumours then show a marked tendency to invade a number of organs, such as mesonephros, metanephros, gonad, skin, intestinal coat, lung, liver, etc. Carcinoma cells show a marked tendency to invade similar tissues to sarcomas, although they retain some capacity to proliferate as dense gatherings or secondary nodules.

Direct histological studies of growing tumours were described by Dr. B. Sylvén (Stockholm). With epithelial tissues in both normal regeneration and tumour growth, the connective tissue exhibits the following changes : (1) a general increase in water content ; (2) an increased metachromatic component and (3) appearance of alkaline phosphatase in the ground substance. The extent of the changes gives a measure of the growth-rate and degree of malignancy of the tumour. With normal regeneration, the original connective tissue structure is reversibly restored with cessation of growth. The actual invasion of neighbouring tissues by tumour cells is seen to occur through channels and cavities already present in the normal structures ; in addition, a considerable release of enzymes, particularly proteases, occurs. Such a transformation suggests a primary defect in the organization of the malignant cell membrane leading to increased permeability. Incidentally, malignant cells also show an increased permeability to glucose. Such a penetration of enzymes could remove surface adsorbed protein and account for the decreased adhesiveness and high negative charge of tumour cells.

Prof. K. Setälä (Helsinki) then described some experiments which may give a bearing on the actual mechanism of the cellular transformation which gives rise to the altered properties of tumour cells. He described how a number of surface-active agents of the 'Tween' detergent type can act as powerful promoters in carcinogenesis ; that is, they lead to a marked increase in tumour incidence when combined with a given carcinogen. Electron microscopy of the epidermal cells of the interfollicular areas of a mouse's back indicate that marked changes in cell contacts with intercellular gaps and bridges are produced by the promoting agents. Surface-active agents which do not act as promoters, on the other hand, lead to an actual hindrance of proliferation and increased regions of close contact between the cells.

Dr. E. H. Mercer (London) also described some of the valuable results he has obtained by high-resolution electron microscopy of cell contacts. Electron micrographs of cell membranes (Birbeck and Mercer) indicate that they consist of a layer structure about 60 A. thick which could correspond to the lipid lying between protein layers, as proposed by Prof. J. F. Danielli. The membranes are generally separated by a distance of 150–200 A., suggesting the presence of a cementing material between the cells. Anaplastic tumours often show changes in their cell contacts as compared with normal tissues. They may show a convoluted surface with only small areas of contact; the contacts are more like those of normal cells during the early stages of tissue formation. The electron microscopy, therefore, supports the view that the surface properties of tumour cells are changed in comparison with the normal cells from which they are derived.

In conclusion, mention may be made of two other techniques which are being applied to the problem of cell movements and cell contacts. Dr. H. Harris (Oxford) described a simple but most effective method which he has applied to the study of groups of white blood cells. A long exposure is made with dark-field illumination. On subsequent development of the plate, the paths of the moving cells are recorded as streaks on the photographic emulsion. This technique is particularly useful for the study of a taxis affecting the over-all direction of cell migration.

Finally, Dr. R. J. Goldacre (London) described an approach based on the use of electronic models. In normal growth and maintenance the transfer of information from cell to cell evidently occurs. Direct contacts between the cell membranes appear to play a part in this, at least in the early stages of development. An electronic model consisting of units ('cells') which can stimulate and be stimulated by others can be designed. By connecting the units together in different groups, various complex patterns of interest in morphogenesis are generated in the system; for example, patterns with polarity, discrete differences between neighbouring units, etc. On the basis of such a picture, it would be expected that a small loss of cell – cell interaction, arising from surface changes, could readily lead to abnormal and uncontrolled growth in tumour tissues.

E. J. AMBROSE

PREDICTING ACADEMIC SUCCESS

THE purpose of a recent investigation by Sigvard Rubenowitz, of the Swedish Council for Personnel Administration, Gothenburg, was to determine the weights which have to be assigned to different tests and biographical data in order to predict success in academic studies*. The freshmen at the three universities in Gothenburg in 1954 were invited to take part in the investigation, the results of which would later be related to success at university as measured by examination results. Freshmen were chosen as subjects for the investigation in order to avoid bias in the results of the tests arising from different academic studies. In all, 440, or 62 per cent, of the freshmen responded to the invitation.

After two years, information about examination results was collected and this was related to the data collected two years earlier.

The data collected and the tests which were given to the students were: (1) grades in the matriculation examination; (2) study habit assessments; (3) intelligence test marks; (4) technical test marks; (5) mathematical–technical test marks; (6) organization test marks; (7) details of interests; (8) psychodiagnostic test assessment; and (9) attitude assessment.

Analysis of the results showed that of 43 female students who studied languages and 18 who were studying psychology the validation data in Table 1 were obtained.

It became clear that, for languages, more time is required for study than for other subjects. In addition, a significant correlation exists between intellectual and matriculation results on one hand and success in language studies on the other. The study habit also appears to be of great importance in the study of languages. With psychology, general intelligence, together with those qualities which find expression in a good matriculation result, are not of such decisive importance as are certain mathematical technical aptitudes and some characterological factors that are measured by the Zulliger test.

Table 1

	Languages, 43 students	Psychology, 18 students
Grades in matriculation examination	0·43	0·12
Study habit inventory	0·38	0·17
Intelligence test	0·40	0·28
Technical test	0·17	0·31
Mathematical–technical test	0·06	0·23
Organization test	0·04	0·28
Psychodiagnostic test	0·15	0·37
Attitude assessment (the 'rigid' pole)	0·21	0·25

With certain male students the subject groups that formed the object of the validation were languages. psychology (philosophy), mathematics (statistics) and zoology (botany). The students of mathematics and statistics were, in general, superior to all others and above all in their intelligence and mathematical–technical ability. The male language students, like their female counterparts, made a significantly poor showing in their examination results.

The validation data in Table 2 were obtained from this inquiry.

Comparing these results with those for female students, the same trend is found except in the case of the matriculation result; this was of most value in prognosis for female students of languages, whereas for male students its value is highest for prognosis of psychological studies.

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* *Occupational Psychology*, 32, No. 3 (July 1958).

Table 2

	Languages, 35 students	Psychology, 15 students	Mathematics, 12 students	Zoology, 10 students
Grades in matriculation examination	0·09	0·53	0·58	0·08
Study habit inventory	0·25	0·14	0·50	0·42
Intelligence test	0·33	0·31	0·82	0·29
Technical test	0·18	0·43	0·47	0·25
Mathematical–technical test	0·22	0·25	0·61	0·06
Organization test	0·34	0·11	−0·04	0·01
Interest blank. (University Arts Faculties Scoring Scheme)	0·06	−0·65	−0·37	−0·30
Interest assessment (Chalmers University Scoring Scheme)		0·49	0·42	
Psychodiagnostic test	0·55	0·62	0·38	0·49
Attitude formula (the 'rigid' pole)	0·17	0·13	−0·08	0·03

At the University of Technology the coefficients of validity in Table 3 were obtained.

It appears that the matriculation examination has a considerably higher prognostic value for these than for those at the University (arts faculties), probably because the courses at the former have to be followed closely and in many respects resemble pre-matriculation studies. For this reason, the matriculation examination can be considered as a job sample test.

A combination of the matriculation results and tests would form the most suitable instrument of prognosis for these students, provided that the multiple regression calculation stands up to cross-validation in a renewed investigation.

Table 3

	219 students
Grades in matriculation examination	0·67
Study habit inventory	0·30
Intelligence test	0·15
Technical test	0·22
Mathematical–technical test	0·32
Organization test	0·09
Interest blank	0·20
Psychodiagnostic test	0·22
Attitude assessment (the 'rigid' pole)	0·01
Entrance qualifications (matriculation grades + previous factory experience)	0·52
Best combination of six prognostic variables	0·77

At the University of Economics the criterion used was the average result in all the subjects passed. The coefficients of validity were as shown in Table 4.

Table 4

	49 students
Grades in matriculation examination	0·22
Study habit inventory	0·46
Intelligence test	0·18
Technical test	0·31
Mathematical–technical test	0·34
Organization test	0·18
Interest blank	0·16
Psychodiagnostic test	0·36
Attitude assessment	−0·04
Best combination of seven prognostic variables	0·77

The study habit inventory had the highest validity here, followed by Zulliger's psychodiagnostic test and the mathematical–technical test. The low validity of the matriculation result is worthy of note.

INDUSTRY AND GOVERNMENT IN CANADA

In his Messel Lecture, "Industry and Government in Canada", before the Society of Chemical Industry at Montreal on September 15, the Rt. Hon. C. D. Howe, P.C., reviews changes in the responsibilities of government and the attitude of industry during the past fifty years. When he came to Canada as a graduate engineer in 1908, Mr. Howe said that most people regarded activities at Ottawa as remote and of very little personal concern. Now, an industrial revolution and relatively sudden highly scientific industrial and military developments, with the rise of the Welfare State, had transformed the scale and character of government administrative responsibility. While the population had grown from 6·5 million to 17 million, government expenditure had multiplied about twenty-five times and was now 5,272 million dollars a year. Mr. Howe believed that most Canadian business men to-day recognized that the public demanded services which only government could provide and that many of them not only tolerated government activity but also were prepared to admit that government action could promote the prosperity and welfare of the country. There had also been a similar improvement in the attitude of government towards business in Canada, and his experience as a Minister during 1935–57 led him to believe that the role of industry and commerce in society was better understood than it had been before.

Mr. Howe then referred to some changes in the administrative structure and notably the appearance of what is known in Canada as the Crown Corporation, on which experienced business men gave part-time service as directors. This pragmatic device, analogous to the public corporation in Britain, had received much more extensive use since 1935, and after noting the establishment of the National Research Council as a Crown Corporation, out of the Advisory Council on Scientific and Industrial Research formed in 1916, Mr. Howe described a few examples including some of the twenty-eight Crown Corporations formed during the Second World War in the Department of Munitions and Supply, of which he became Minister in 1940. During and after the War the Department functioned directly as the sole procurement agency for the three Armed Services, and he thought that the Crown Corporation had proved itself to be an efficient device for enabling government to cope with certain new responsibilities thrust upon it by an advancing technology. Generally, he thought that the government should not enter into any business that is competitive with private industry, but certain responsibilities that could not be directed to private industry and certain other responsibilities which no private industry was prepared to undertake were most efficiently discharged through a Crown Corporation, nor did he think the device need be abandoned if private industry later entered the field. He also thought that the Crown Corporations had made an important contribution to better understanding between government and business, and in his twenty-two years experience it had been amply demonstrated that complete co-operation between government and business is a prerequisite of national prosperity.

A NATIONAL TYPE CULTURE COLLECTION OF MARINE BACTERIA

By Dr. J. M. SHEWAN, G. D. FLOODGATE and P. R. HAYES

Torry Research Station, Aberdeen (Food Investigation Organization, Department of Scientific and Industrial Research)

FOR many years now, work has been proceeding at the Torry Research Station on the bacteriology of marine fish and on the changes in flora occurring during spoilage and processing. It has generally been recognized that the identification of most of the organisms concerned is one of extreme difficulty. It has often been impossible to be sure of the correct family or tribe, let alone the species. These difficulties are not, of course, confined to the microflora of fish; they are also encountered through the whole of marine bacteriology and especially in the *Achromobacter*, *Pseudomonas* and *Vibrio* groups.

A primary handicap has been the disappearance of the type species of many of the genera commonly occurring in marine, soil, air or fresh water environments. Thus, so far as we are aware, authentic cultures of *Achromobacter liquefaciens* and *Flavobacterium aquitale*—the type species of these two genera in Bergey's determinative manual[1]—no longer exist in any type culture collection. Moreover, the descriptions of these organisms in the literature as well as those of many related species are completely inadequate. One example of the confusion that has arisen may be mentioned. Wells and ZoBell[2] in 1932 isolated an organism from the skin lesions in the California killifish and named it *Achromobacter ichthyodermis*. In the original description no mention was made of several features now regarded as essential for taxonomic purposes, for example, type of flagellation and mode of dissimilation of glucose, so that the organism could well be placed in either the *Achromobacter*, *Pseudomonas*, *Aeromonas* or *Vibrio* genera. Indeed, it is classified as a *Pseudomonas* in the 1957 edition of Bergey's manual and as *Achromobacter* by Brisou[3]. In 1950, an organism was isolated at this Station from a lesion in plaice and provisionally classified as a *Pseudomonas* sp., and within the past two years Baage and Baage[4] have isolated a bacterium from lesions in Baltic cod which they believed to be identical with *Vibrio anguillarum*[5], the causative organism of the classical 'red disease' of eels. Recent comparison here of these three organisms has shown that they are closely allied, if not identical, and are probably vibrios. Unfortunately, no authentic culture of *Vibrio anguillarum* appears to be available in any type culture collection, so that the complete identity of these three isolates with *Vibrio anguillarum* must remain in doubt.

It is not surprising, therefore, that investigators frequently state that the bacteria that they have isolated do not fit any description given in Bergey's manual or any other determinative system. Consequently, a multiplicity of species, nomenclatures and taxonomic groupings has arisen. We have recently examined more than 100 cultures, 70 from Scandinavia and 30 from North America and all from marine sources. In only about 30 instances did our taxonomic positioning agree with that of the senders, simply because of the divergence of opinions as to which characters are of taxonomic significance.

It is, of course, recognized that a chief difficulty in classifying bacteria from air, soil and water is that the available diagnostic tests, which arose mainly from the detailed studies of animal and human pathogens, yield almost invariably negative results. It is clear that a much more detailed study of the non-pathogens is required and in particular of the Gram-negative asporogenous rods—the *Achromobacter*, *Pseudomonas*, *Flavobacterium* and *Vibrio* groups—to reduce the present chaos to order. New tests of taxonomic significance will have to be found and will only be forthcoming from a thorough study of the biology, physiology and biochemistry of these groups in question.

To begin such a study two essentials at least are required.

(1) The re-isolation and full description of the type species mentioned above, or, where this is impossible, an agreement among taxonomists that a particular organism, known to exist, shall in future be designated the type culture.

(2) The setting up of type culture collections so that cultures are available for comparative purposes: frequently, papers are published that describe apparently new species, none of which has been kept viable or been deposited in a type culture collection.

There appear to be few type culture collections of marine bacteria anywhere outside of the United States. Prof. C. E. ZoBell at the Scripps Institute, La Jolla, California, and Prof. C. E. van Niel at the Hopkins Marine Station, Pacific Grove, California, both maintain small but valuable collections. A few marine strains are held in private collections and at the Pasteur Institute, Paris, and the Microbiological Institute, Delft, and, no doubt, elsewhere. For years the Torry Research Station has maintained a small collection of bacteria mainly from marine fish and solar salts. The need, however, of putting this collection on a more permanent basis and of more detailed studies of the various groups, with the view of better taxonomy, has now been recognized. Marine bacteria play an important part not only in fish spoilage but also in the deterioration of submerged materials, nets, seaweeds, as well as in the biological cycles in the sea. As a result of consultations between various Government Departments, the Development Commission and the University of Aberdeen, funds and personnel have been made available for broadening the basis of the collection held at Torry so as to include bacteria from all marine sources and for a start to be made on more detailed studies of certain selected groups. The present collection, which will form one of the British national collection of type cultures, comprises some 200 named strains of marine bacteria in addition to several hundred recently isolated unnamed strains. All these organisms are at present maintained on culture media and work is now proceeding to test the best method for their long-term preservation.

The collection, though small, is already becoming known to many research workers. Last year more than 100 cultures were sent to laboratories all over the world, but it will take some time to develop it and to prepare a catalogue.

Meantime, bacteriologists are invited to deposit cultures of marine bacteria in the collection, particularly so that their isolates may not be lost but be made available for future comparison. In this way it is hoped that some measure of progress may be made in establishing, on more solid foundations than hitherto, the taxonomy of marine bacteria.

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SOME NEW NEUROMUSCULAR BLOCKING AGENTS

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FOR muscular relaxation in anæsthesia, suxamethonium has the advantage of brevity of action but the disadvantage of possessing no satisfactory antagonist and of sometimes causing post-operative muscle pains and stiffness[1]. Laudexium (laudolissin)[2] is antagonized by neostigmine and does not, so far as we know, cause muscle pains, but it is of longer duration of action than suxamethonium. It occurred to us that it might be possible to prepare an agent combining the valuable properties of both compounds by incorporating some of the chemical features of each into one molecule.

Three series of compounds were investigated. *Type I : Symmetrical bis-esters.* These were prepared by (*a*) the quaternization of N-alkyltetrahydropapaverines with a suitable ω-bromoalkyl ester or (*b*) the reaction of tetrahydropapaverine with an ω-bromoalkyl ester, and quaternization of the resulting bis-tertiary amine with an alkyl halide or sulphate. *Type II : Unsymmetrical mono-esters,* which were obtained from the dialkylaminoalkyl esters of ω-bromo-aliphatic carboxylic acids by quaternization with an alkyl halide, and subsequent treatment of the product with an N-alkyltetrahydropapaverine. *Type III : Symmetrical bis-amides.* The reaction of dicarboxylic acid chlorides with excess ethyleneimine yielded bis-amides of structure :

$$Cl—(CH_2)_2—NH—CO—(CH_2)_n—CO—NH—(CH_2)_2Cl$$

which, after conversion to the corresponding di-iododerivatives, were then quaternized with N-alkyltetrahydropapaverines to yield the required products. The use of phosgene instead of a dicarboxylic acid chloride resulted in the corresponding urea derivatives (IV).

All compounds were examined by intravenous administration to cats, maintained by artificial ventilation and prepared for recording arterial blood pressure and the isometric twitch of the tibialis anterior muscle in response to stimulation of its motor nerve, as described by Paton and Zaimis[3]. The potencies and durations of the neuromuscular blocking actions of the new compounds were compared with those of suxamethonium chloride, or occasionally of (+)-tubocurarine chloride or laudexium methosulphate. Neostigmine methosulphate was given in antagonism tests on some of the new compounds studied. All doses are expressed as weights of salts.

In order to establish norms of potency and duration all doses of the three reference compounds that caused more than 74 and less than 100 per cent depression of the tibialis twitch in all experiments between June 1951 and June 1956 were pooled to obtain overall mean values. These showed that the ratio of potencies in the cat of suxamethonium : (+)-tubocurarine : laudexium was 1·0 : 0·16 : 0·28, and the corresponding ratio of durations was 1·0 : 4·6 : 4·0. Laudexium did not differ significantly from (+)-tubo-

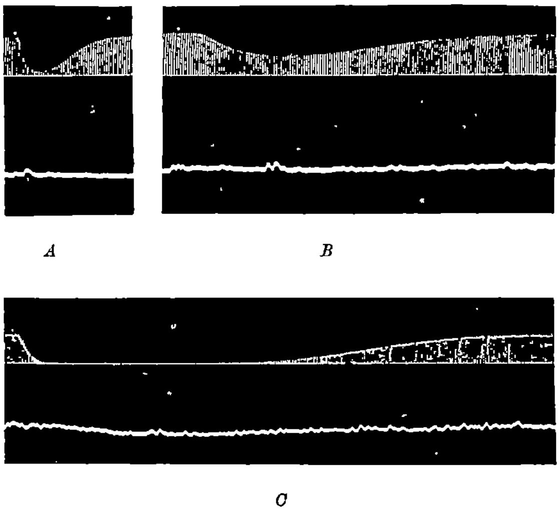

Fig. 1. Effects of suxamethonium and compound 43 on neuromuscular conduction and blood pressure in the cat. Upper tracing, tibialis twitch in response to stimuli to motor nerve, repeated at 6/min.; lower tracing, carotid blood pressure; dot indicates time of dosage. *A*, 60 μgm./kgm. suxamethonium chloride; *B*, 7, and *C*, 10 μgm./kgm. compound 43 bromiodide

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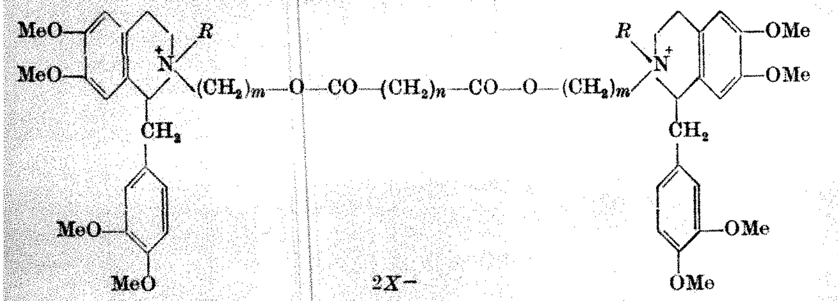
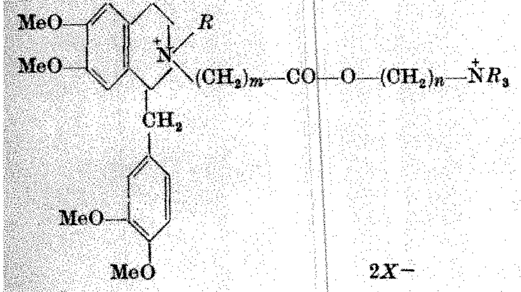


(I)



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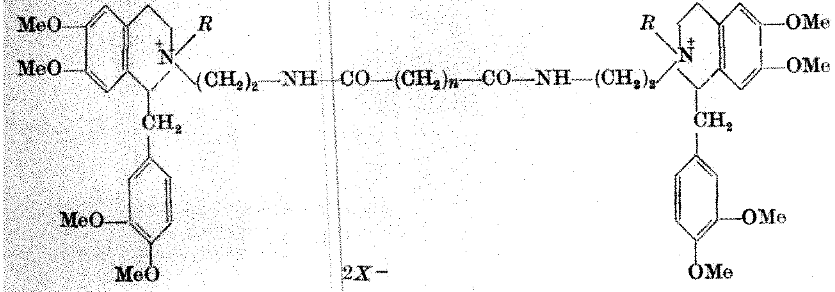

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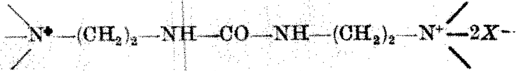

$$-N^{+}-(CH_2)_2-NH-CO-NH-(CH_2)_2-N^{+}-\ 2X^{-}$$

(IV)

(—N⁺ = N-alkyltetrahydropapaverinium)

curarine in duration, although, in an initial more limited series of experiments published previously, it appeared to be longer in duration[4].

The results obtained in the cat with the new compounds described above are illustrated in Fig. 1 and summarized in Table 1, from which it will be seen that the only compound more potent than suxamethonium was the unsymmetrical mono-ester, No. 43, and the only compound briefer than suxamethonium was the symmetrical *bis*-ester, No. 41.

Compound 43 was about seven times as active as suxamethonium. It was of long duration of action and did not show antagonism by neostigmine. It was given to one cat at a dose of 500 μgm./kgm. (that is, about 50 times a fully effective dose). Blood pressure fell to about 82 per cent and then rose to about 150 per cent of its value before treatment; the cat survived for 1 hr., and was then destroyed.

Compound 41, although relatively weak, was antagonized by neostigmine in the cat. The cumulative actions of suxamethonium and compound 41 were compared in three cats, in which series of successive equal doses of one substance were given at equal intervals of time. In these experiments, later doses of compound 41 did not last longer in effect than the initial dose, but later doses of suxamethonium were both more long-acting and more effective than the earlier. Table 2 illustrates this finding in one such experiment.

One cat received 20 mgm./kgm. compound 41, which was about six times a fully effective dose. This caused a complete neuromuscular block lasting 34 min. to 75 per cent recovery. There was a 43 per cent fall in blood pressure. At 2¾ hr. after this dose, the cat was alive; a dose of 40 mgm./kgm. then caused a further fall in blood pressure and the cat died.

In conclusion, a search for neuromuscular blocking agents resembling (+)-tubocurarine in mode of action, but briefer in duration, resulted in the

Table 1. SUMMARY OF RESULTS OBTAINED WITH COMPOUNDS IN CATS. BLOOD PRESSURE OBSERVATIONS MADE AT FULLY EFFECTIVE DOSES

Compound						No. of cats	Approximate relation to suxamethonium (= 1)		Fall in blood pressure	Neostigmine antagonism
Type	No.	*R*	*m*	*n*	2*X*		Potency	Duration		
Bis-ester (I)	31	CH_3	2	2	2Br	3	0·06	5·4	×	+
	32	CH_3	2	1	2Br	8	0·15	2·6	+	+
	35	CH_3	2	4	2Br	2	< 0·01	—	+	—
	36	C_2H_5	2	1	2Br	2	< 0·01	—	—	—
	38	CH_3	3	1	2Br	3	0·3	9	×	+
	39	CH_3	2	0	2Br	3	0·002	—	+	—
	41	CH_3	3	0	2Br	8	0·025	0·5	×	+
Mono-ester (II)	43	CH_3	5	2	BrI	4	7·0	6·3	×	×
	47	CH_3	4	3	BrI	3	< 0·5 > 0·05	8	×	—
Bis-amide (III)	45	CH_3	0	0	2I	2	0·02	2·5	×	+
Bis-amide (IV)	44	CH_3	0	0	2I	2	0·01	1·5	×	+

× = No effect; + = some effect; — = not tried

Table 2. Cat Tibialis. Extent and Duration of Neuromuscular Depression caused by Suxamethonium and Compound 41, given in Doses repeated at 20-min. Intervals

Effect	Suxamethonium, 50 μgm./kgm.				Compound 41, 3 mgm./kgm.			
	1st dose	2nd dose	3rd dose	4th dose	1st dose	2nd dose	3rd dose	4th dose
Depression tibialis twitch (per cent)	69	83	88	94	69	65	74	75
Duration to 75 per cent recovery (sec.)	190	290	370	340	130	120	150	140

synthesis of three series of bis-quaternary ammonium salts, all possessing structural features in common with laudexium and suxamethonium.

The only compound more active than suxamethonium in the cat was the unsymmetrical mono-ester, No. 43, which was about seven times as active as the reference compound and appears to be one of the most powerful synthetic neuromuscular blocking agents known. It was of long duration of action and did not show antagonism by neostigmine. Cats maintained by artificial ventilation tolerated very large doses.

The only compound briefer in action than suxamethonium was the symmetrical bis-ester, No. 41, which was of relatively low potency. It was not hypotensive at fully effective doses, but relatively large doses caused falls in blood pressure. It was not cumulative when given in repeated doses, and was antagonized by neostigmine in the cat.

This article represents the substance of a communication to the eleventh Congress of the Italian Society of Anæsthesiology, held in Venice on September 12–15. Full chemical and pharmacological details will be published elsewhere. We wish to thank Dr. J. G. Bourne and Mr. G. M. Timmis for helpful discussions, Mr. R. T. Brittain for some experimental contributions, and Mrs. E. Nield and Mr. I. J. Gibson for technical assistance. We are also indebted to the Directors of Allen and Hanburys, Ltd., for permission to publish this work.

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HISTOCHEMICAL CHANGES IN KIDNEYS AND ADRENALS OF RATS MADE HYPERTENSIVE BY THE GOLDBLATT METHOD

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AND
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GOLDBLATT and his colleagues[1] showed that partial constriction of the renal artery and removal of the opposite kidney induces persistent hypertension. In the dog and rabbit, hypertension is transient unless the opposite kidney is removed, but in the rat[2,3] persistent hypertension occurs after constriction of one renal artery without contralateral nephrectomy. In such animals hypertensive vascular lesions, similar to those found in malignant hypertension in man, develop in the opposite or 'untouched' kidney but are never found in the kidney with renal artery constriction (the 'clipped' kidney). Floyer[4,5] demonstrated that in rats with hypertension of several weeks duration, produced by renal artery constriction and before vascular lesions had developed in the contra-lateral kidney, removal of the clipped kidney restored the blood pressure to normal in a few hours, but the removal of both kidneys had no effects. Since denervation experiments have no effect upon this experiment, Floyer[4,5] suggested that the clipped kidney secreted a substance (renin ?) which altered the blood pressure regulating function of the untouched contra-lateral kidney. Since adrenalectomy abolishes hypertension the adrenals presumably are part of the pressor mechanism which comes into operation when the kidney is rendered abnormal by clipping.

A variety of histochemical techniques were applied to both kidneys and adrenals of rats on which partial renal artery constriction had been carried out by the method of Wilson and Byrom[2]. Some animals were subjected to exactly the same procedure as above but using larger clips which simply hung as a loose collar around the artery and did not compress it at all—this did not give rise to hypertension but caused some decrease of succinic dehydrogenase reaction. The following histochemical reactions were studied at varying times following these two types of ligation (clipping) : succinic dehydrogenase, acid and alkaline phosphatase, 5-nucleotidase, simple esterase, lipid, cholesterol and periodic acid Schiff-positive sub-

Table 1

	Acute animals	Chronic animals
Succinic dehydrogenase	In clipped kidney decrease within 2 days, persisting to 8 days	Clipped kidney normal. Contra-lateral kidney almost normal but negative in patches
Phosphatases Alkaline phosphatase Acid phosphatase 5-Nucleotidase	Reduction of all three phosphatases, greatest in clipped kidneys. Alkaline phosphatase normal by 8 days. 5-Nucleotidase normal by 18 days. Acid phosphatase still decreased at 18 days	All three phosphatases decreased in contra-lateral kidneys. Almost normal in clipped kidneys
Simple esterase	Increased in both kidneys	Decreased in both kidneys
Lipids and cholesterol	Accumulation of lipid in glomeruli of both kidneys at 2 hr. Later accumulation in groups of tubules most obvious in contra-lateral kidney. No cholesterol demonstrated	Tubular lipid only in clipped kidneys. Contra-lateral kidney shows lipid and cholesterol in glomeruli

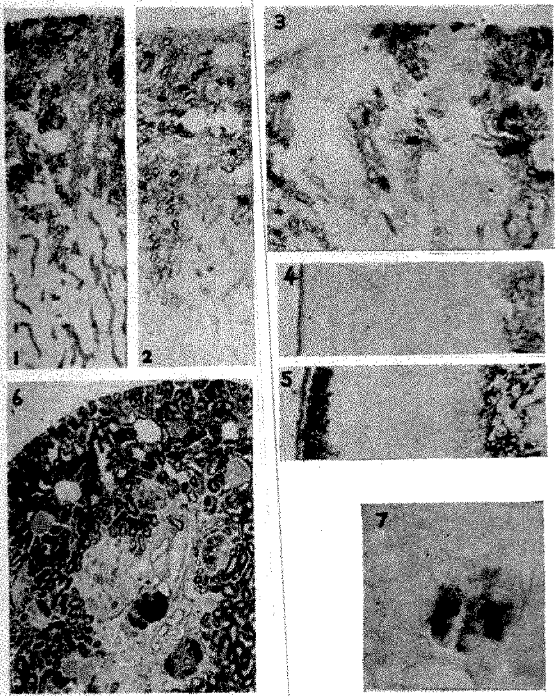

Fig. 1. Succinic dehydrogenase reaction in normal rat kidney. 2, Succinic dehydrogenase reaction in rat kidney (clipped side) with partial clipping of renal artery for five days. Greatly reduced reaction. 3, Succinic dehydrogenase reaction in contra-lateral kidney of rat with renal artery of opposite kidney partly clipped for two months. Reaction almost negative in parts, normal in some patches. 4, 5-Nucleotidase in adrenal of normal rat. Reaction is restricted to the capsule, the narrow zona glomerulosa and the medulla. 5, 5-Nucleotidase in adrenal of rat with one kidney partly clipped for two months. Great increase in zona glomerulosa and in 5-nucleotidase reaction in glomerulosa and medulla. 6, Sudan black (lipid) preparation of contra-lateral kidney of rat with renal artery of opposite kidney partly clipped for two months. Note accumulation of lipid in tubules and in glomeruli. 7, Same animal as in Fig. 6. Schultz cholesterol preparation. A single glomerulus showing accumulation of cholesterol

stances. 'Acute' animals in this account means those animals which have been clipped for periods up to a few weeks and showed no hypertension. 'Chronic' refers to those animals which had been clipped for some months and had developed hypertension. The results are shown in Table 1.

In all animals from 2 days on there was an increase in the width of the zona glomerulosa of the adrenals (said to produce the hormones responsible for electrolyte regulation) accompanied by an increased 5-nucleotidase reaction. There was a decrease of alkaline and acid phosphatase in the cortical sinusoids in the acute animals, and an increase of acid phosphatase in the chronic animals.

Light clipping of one renal artery thus produces changes in activity and distribution of enzymes and accumulation of lipid in both kidneys within two hours. More profound changes occur in both kidneys and adrenals within two days. Within three weeks most, but not all, of these changes have returned to normal in the clipped kidneys. In the contra-lateral kidneys some changes persist into the chronic stage and presumably play a part in the development of pathological changes there. The changes in the adrenals persisted or increased in chronic (hypertensive) animals. Attention should be directed to the accumulation of cholesterol in the glomeruli of the contra-lateral kidney in chronic animals, to the fact that the histochemical changes occur very quickly and precede both pathological changes and hypertension and to the fact that even placing a clip in position around the renal artery without any compression at all causes changes in the succinic dehydrogenase activity of the clipped kidney.

The cause of these changes is not yet established; but their existence must lead to speculation as to whether the renal artery itself, in response to irritation, is not capable of secreting a substance which, by affecting the clipped kidney, causes the whole cycle of events which lead to the initiation of hypertension.

This work was assisted by a grant from the Medical Research Council to Dr. A. Pasqualino. We are greatly indebted to Dr. M. A. Floyer of the Medical Unit, The London Hospital, Whitechapel, for the provision of clipped rats for this work and for much helpful comment and details of literature.

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MELANIN: A NATURALLY OCCURRING CATION EXCHANGE MATERIAL

By Dr. LAURENS P. WHITE

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It is the purpose of this report to present results which demonstrate that melanin from two different sources has strong cation exchange activity.

Although melanin is a substance of immense sociological and physiological significance, little is known of its structure, reactivity, physical state, or of the functions which it may possess. Greenstein[1], Mason[2] and others[3] have characterized the elementary composition, some precursors and certain physical facts about some plant and animal melanins. Commoner *et al.*[4] have shown that melanin contains stable free radicals, and have commented on the chemical significance of this fact.

It has become generally accepted that melanins are complex polymeric substances intimately bound to protein. *In vivo*, melanin is thought to exist as particles of 0·1–1·0μ diameter. Crude preparations of melanin granules are completely insoluble in water and all common organic solvents; the granules are soluble in hot aqueous sodium hydroxide, in which melanin probably undergoes depolymerization; melanin is apparently soluble in dilute sodium carbonate[1]. Dried preparations of granules take up 2–4 times their weight in water. These physical characteristics: complex polymeric structure (thought to be derived from phenolic precursors), insoluble particulate state, Table 1. 8·13 GM. OF DRY MELANIN PARTICLES

Supernatant	Volume ml.	*p*H	Sodium m.equiv./l.	Sodium m.equiv.	Chloride m.equiv./l.	Chloride m.equiv.
Water wash 1	20·0	6·87	7·30	0·146		
Water wash 2	20·0	6·91	17·83	0·357		
Water wash 3	20·0	7·04	13·95	0·279		
NaCl solution	20·0	6·52	79·60	1·590	81·1	1·620
NaCl supernatant	17·4	6·67	47·80	0·813		
Water wash 4	15·5	7·43	23·85	0·312		
Water wash 5	17·0	7·50	15·00	0·255		
Water wash 6	17·5	7·58	9·45	0·165		
HCl 0·1 *N*	20·0		0·50	0 010		
HCl supernatant	27·3	2·20	40·40	1·090		
NaOH supernatant	16·8	7·94			60·5	1·011
NaCl supernatant	20·0	7·50			69·1	1·382
Water wash 7	18·0	7·40			34·1	0·614
Water wash 8	18·5	7·12			28·2	0·521
Water wash 9	17·5				9·6	0·168
NaOH 0·1 *N* supernatant	13·0				8·6	0·119

and the ability to take up large amounts of water are strongly reminiscent of some of the chief characteristics of synthetic organic ion exchange resins[5]. Therefore, the ion exchange activity of partially purified melanin was examined.

The sources of the melanin used in the following experiments were the transplantable Harding–Passey tumour of mice, taken after eight weeks of growth in *C57/dba* hybrids, and the ink from the ink sac of the Pacific coast squid (*Loligo opalescens*). The tumour (657 gm.) was homogenized in dilute sodium chloride solution and the granules separated by high-speed centrifugation, as described by duBuy *et al.*[6]. The granules obtained were uniform in colour, size and shape. From the starting weight of tumour, 28 gm. of wet melanin granules were obtained. On drying over calcium chloride *in vacuo* a final yield of 13·0 gm. of coal-black lumps was obtained. Squid ink granules were obtained by repeated washing of the particles with water, and high-speed centrifugal separation. The very small particle size of both preparations prevented the use of columns or conventional filters. The washed granules were incubated with dilute saline, washed further and then treated with 0·1 *N* hydrochloric acid. Further centrifugation gave the hydrochloric acid supernatant. All these centrifugal supernatants were collected separately, the *p*H was measured, and the sodium ion content measured. The *p*H of the granules treated with hydrochloric acid was then adjusted to 7·9, the granules washed, treated again with sodium chloride, washed further, and then incubated with hydroxyl, formate or acetate. The *p*H and chloride ion content of each supernatant were measured.

A similar study was performed with aqueous eosin, in which granules were incubated with the eosin solution at neutral *p*H, then washed until the supernatant was free of eosin, treated with 0·1 *N* hydrochloric acid, and the eosin content of the hydrochloric acid supernatant measured.

Table 1 gives a résumé of results in a typical experiment. Incubation of washed melanin granules with sodium chloride appeared to decrease the sodium ion content of the supernatant fluid. Most of this 'lost' sodium ion content reappeared on further washing of the granules, and probably had been retained in the interstices of the granules. Hydrochloric acid, however, eluted a very considerable amount of sodium ion from the melanin with a marked drop in *p*H. It should be emphasized that the amount of sodium ion content found in the supernatant may represent only about half of that actually eluted, for approximately 20 ml. of fluid remained with the granules after each centrifugation.

The results with anions were equally uniform. Regardless of the eluting anion employed, it was not possible to demonstrate anion elution from melanin.

Similar experiments using eosin gave corroboratory results. At neutral *p*H incubation of melanin granules with aqueous eosin markedly decreased the optical density of the eosin solution. After repeated washing of the melanin granules with water, until no absorption at 515 mμ was present in the supernatant, the granules were treated with 0·1 *N* hydrochloric acid. The optical density of the hydrochloric acid supernatant was considerably higher than that of the wash solutions, despite further dilution of eosin. (Treatment with hydrochloric acid of melanin particles not incubated with eosin did not produce any material in the supernatant absorbing at 515 mμ.)

The cation exchange activity of squid melanin was similar to that of mammalian melanin. Squid melanin particles appeared to have a higher level of cation-exchange activity than did the mammalian particles; but this may be due to the greater contamination of the latter.

The results of these experiments indicate that melanin granules from both a mammalian and an invertebrate source have the capacity to act as cation-exchange materials of considerable activity. Bersin[7], who has discussed naturally occurring cation exchangers in man, includes tyrosinase, ceruloplasmin, ascorbic acid oxidase and transferrin. To this short list melanin can be added.

The significance of this cation-exchange activity of melanin in relation to function is speculative, but of great interest. Cassidy[8] has shown that some cation exchange polymers can also absorb electrons. The distribution of melanin in normal animals in areas exposed to light, and its increase in the skin after exposure to sunlight or ionizing radiation make for interesting speculations as to the importance of the ion-exchange activity of melanin as one of its more important functions.

This work was supported by a grant (*CY* 2914) from the National Cancer Institute, National Institutes of Health, Bethesda, Maryland.

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INCORPORATION OF CARBON-14 DIOXIDE INTO SUGARS BY DARKENED COTYLEDONS FROM ETIOLATED SUNFLOWER SEEDLINGS

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THE consumption of fat and the concomitant production of sugars by germinating sunflower seedlings have long been known, and low respiratory quotient values have been observed to accompany these changes. Recent experiments[1] with etiolated sunflower seedlings have shown that the acids of the tricarboxylic acid cycle also accumulate during germination. One possible explanation of these facts is that fixation of carbon dioxide in the β-carboxylation of pyruvate or phosphoenol pyruvate to yield oxalacetate or malate contributes to this accumulation, as happens when low respiratory quotient values accompany malic acid accumulation in darkened *Kalanchoë* leaves.

Accordingly, carbon-14 dioxide was fed to darkened cotyledons (usually 2–6 gm. fresh weight), which were cut from 5-day-old sunflower seedlings which had been grown in the dark at 20° C. The darkened vessels containing the tissue were flushed with air free from carbon dioxide for 1 hr. before the introduction of the carbon-14 dioxide. After exposure to carbon-14 dioxide (about 0·5 mc.) for periods of 5 sec.–12 hr., the cotyledons were exhaustively extracted with 80 per cent ethanol. Components in this extract were identified by two-dimensional chromatography on Whatman No. 1 paper with *tert.* amyl alcohol/formic acid/water and propanol/ammonia as developing solvents. Amino-acids were also chromatographed separately after fractionation of the ethanolic extract on ion-exchange resins. Radioactive components were detected by radioautography and the carbon-14 content of individual substances was assayed by counting the active areas on the developed chromatograms. Since all experiments were performed on seedlings of the same age, it has been assumed that all these seedlings contained their various constituents in closely similar proportions, and that the comparison of the relative amounts of radioactivity in the individual substances after varying periods of exposure to carbon-14 dioxide is valid. The malic acid and the glucose moiety of sucrose were degraded by procedures based on fermentation by *Lactobacillus arabinosus* and *Leuconostoc mesenteroides*, respectively.

The most striking result shown in Table 1 is that in experimental periods longer than 5 min. sucrose was the most heavily labelled compound. In earlier work on other tissues fed with carbon-14 dioxide in the dark the free sugars were either unlabelled or possessed only weak activity[2–4]. Even in *Kalanchoë*, which possess exceptionally high powers of dark fixation of carbon dioxide, no labelled sugars have been detected[5].

Table 1. DISTRIBUTION OF CARBON-14 AMONG COMPOUNDS EXTRACTED WITH 80 PER CENT ETHANOL FROM SUNFLOWER COTYLEDONS WHICH HAD BEEN EXPOSED TO CARBON-14 DIOXIDE IN THE DARK

Substance	Period of dark carbon-14 dioxide fixation			
	5 sec.	45 sec.	5 min.	30 min.
Sucrose	0·0	3·6	294·8	2,242·3
Glucose	0·0	trace	20·5	81·0
Fructose	0·0	trace	19·5	109·8
Malate	48·0	412·3	132·5	242·7
Citrate	0·0	22·1	54·0	105·2
Succinate	trace	31·3	10 0	13·0
Fumarate	1·3	44·5	2·8	5·5
Aspartate	8·5	11·2	41·4	71·9
Glutamate		2·5	1·4	6·0
Alanine	4·5	58·1	26·1	30·8
Serine		0·7	2·4	8·4
Glycine		0·9		
	62·3	587·2	605·4	2,916·6

The results are expressed as c.p.m. × 10^{-3}.

With shorter periods of carbon-14 feeding, the bulk of the radioactivity was in malate and in related acids and amino-acids, suggesting that carbon-14 dioxide was incorporated by a β-carboxylation of pyruvate or phosphoenol pyruvate to give malate either directly or indirectly by way of oxalacetate. The enzyme system catalysing this incorporation is as yet unidentified, though Walker (private communication) has detected malic enzyme in the cotyledons of 5-day-old sunflower seedlings.

Table 2 shows the distribution of carbon-14 within malic acid and the glucose moiety of sucrose isolated from the cotyledons which had been exposed to carbon-14 dioxide for 15 min. in the dark. In the malate the isotope was essentially confined to the carbon atoms of the carboxylic groups, and it is noteworthy that the carbon-14, presumably first incorporated into the β-COOH group, was after 15 min. rapidly appearing in the α-COOH group. The radioactivity in the hexose was largely confined to the central carbon atoms, that is, carbon atoms 3 and 4.

The identification of malate as an early product of carbon-14 dioxide incorporation and the subsequent accumulation of label in sucrose suggest that malate is converted into sucrose. This conversion could occur by way of the reactions of glycolysis in reverse, with malate giving rise to either pyruvate directly or phosphoenol pyruvate via oxalacetate as the first reactions. In either case, the carbon-14 present in the β-COOH of the malate would be released as carbon dioxide. The label in the α-COOH group

Table 2. DISTRIBUTION OF CARBON-14 IN MALIC ACID AND IN THE GLUCOSE MOIETY OF SUCROSE FROM SUNFLOWER COTYLEDONS WHICH HAD BEEN EXPOSED TO CARBON-14 DIOXIDE FOR 15 MIN. IN THE DARK

Glucose		Malic acid	
—CHO	5·2	—COOH	30·5
—CHOH	4·2	—CHOH	1·9
—CHOH	35·7	—CH_2	1·6
—CHOH	48·6	—COOH	66·0
—CHOH	3·0		
—CH_2OH	3·3		
	100·0		100·0

Values expressed as percentages.

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would be retained in the pyruvate or phosphoenol pyruvate and incorporated as carbon atoms 3 and 4 of the hexoses. Broadly the isotopic distribution reported for the glucose moiety of sucrose in Table 2 provides support for the reactions outlined. Since quantitative physiological studies[1] have demonstrated that, at the same stage of seedling growth, the fatty food reserve in the sunflower cotyledons is being rapidly converted into sucrose, a possible inference is that malate is an intermediate in this fat into carbohydrate conversion.

The glyoxylate cycle of Kornberg and Krebs coupled with a pathway such as that mentioned for the conversion of malate into sugar provides a possible mechanism for the conversion of fat into sugar in sunflower cotyledons. The enzymes relevant to the glyoxylate cycle, shown by Kornberg and Beevers to be present in castor-bean seedlings, have recently been demonstrated in cell-free preparations from the cotyledons of germinating sunflower and peanut seedlings[6]. In addition, feeding experiments with radioactive acetate have provided evidence for the operation of this cycle in the intact cotyledons[6,7]. The operation of the cycle in the cotyledons used in the present experiments could account for the spread of the carbon-14 label from the β-COOH group to the α-COOH group of the malic acid (see Table 2).

The metabolic significance of the incorporation of carbon-14 dioxide into the sunflower cotyledons in the dark is at present unknown. Clearly it may have resulted either from a net uptake of carbon dioxide by the tissue or simply from such incorporation as presumably occurs in any system normally in equilibrium with an atmosphere containing carbon dioxide when carbon-14 dioxide is introduced into that atmosphere. The low respiratory-quotient values (0·5–0·6) which have been observed[1] in 5-day-old sunflower seedlings could result from fixation of carbon dioxide, but can also be explained in terms of the operation of the glyoxylate cycle.

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EFFECT OF GROWTH SUBSTRATES ON ISOCITRATASE FORMATION BY *PSEUDOMONAS OVALIS* CHESTER

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ISOCITRATASE, which catalyses the aldol cleavage of isocitrate to succinate and glyoxylate[1–3], is thought to play an essential part in the biosynthesis of cell constituents by micro-organisms growing on acetate as sole carbon source[4–9]. The levels of isocitratase found in bacterial extracts vary widely with the substrate on which the cells are grown[10] (Table 1), suggesting that the enzyme operates only when net formation of C_4-compounds from acetate is necessary for growth. This was tested by incubating a washed suspension of *Pseudomonas ovalis* Chester, which had been grown on acetate as sole carbon source[6], in growth media containing either 50 m*M* acetate or 50 m*M* succinate as carbon sources. Growth of the organisms was followed nephelometrically. At known times, samples of the growing cultures were centrifuged, suspended in 10 ml. of 0·9 per cent potassium chloride, disintegrated by supersonic vibration (at 25 kc./s., generated by a 600 W. Mullard magnetostrictor oscillator at 3·5 amp.) for 2 min., and centrifuged for 15 min. at approximately 20,000*g*. The isocitratase activity of the supernatant solutions was determined by a modification of the method of Olson[11], by measurement in a Cary recording spectrophotometer of the rate of change of optical density at 252 mμ, consequent upon the formation of glyoxylate semicarbazone, when cell extracts were incubated at *p*H 6·0 with semicarbazide and isocitrate.

Table 1. SPECIFIC ACTIVITY OF ISOCITRATASE IN EXTRACTS OF *Pseudomonas ovalis* CHESTER GROWN ON DIFFERENT SUBSTRATES

Growth substrate	Specific activity (μmoles of glyoxylate formed/mgm. protein/hr.) at *p*H 6·0
Acetate	2·78
Glucose	< 0·01
Citrate	0·13
Succinate	0·25
Malate	0·15
Fumarate	0·06
Lactate	0·11
Alanine	0·09
Aspartate	0·08
Glycine	0·14
Glycollate	0·08

Cells used for inoculations of growth media had been maintained on 50 m*M* acetate medium (ref. 6) solidified with 2 per cent agar. Growing cultures were harvested at the approximate mid-point of logarithmic growth and washed with 0·9 per cent potassium chloride. Cell extracts were prepared as described in the text. Isocitratase was estimated spectrophotometrically, by the rate of change of optical density at 252 mμ due to the formation of glyoxylate semicarbazone, in the assay procedure of Olson (ref. 11). The identity with glyoxylate semicarbazone of the material absorbing ultra-violet was confirmed by preparation of the 2,4-dinitrophenylhydrazone from it after the assays, and identification of this derivative by paper chromatography (ref. 13). In all cases, glyoxylate was the only keto compound formed.

The results obtained (Fig. 1) show that these cells grown on acetate contained isocitratase at high specific activity at zero time, and that, when placed in fresh acetate growth medium, the isocitratase continued to be formed at a rate parallel to the formation of cell material. The cells placed in succinate growth medium, which initially contained isocitratase

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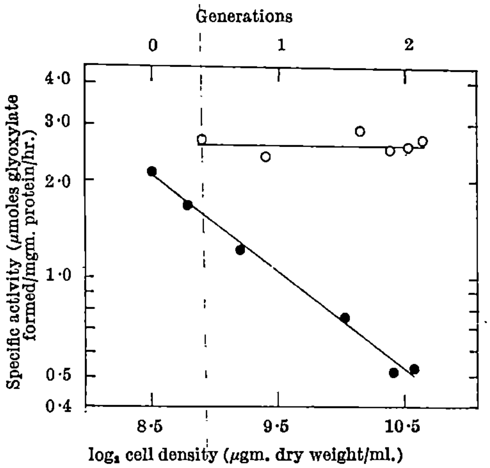

Fig. 1. Variation of specific activity of isocitratase with cell growth. *Pseudomonas ovalis* Chester grown on acetate, incubated in growth media containing 50 m*M* acetate (○—○) or 50 m*M* succinate (●—●) as sole carbon sources

at similar high specific activity, did not continue to form isocitratase, and the specific activity of the enzyme under these conditions of growth fell sharply with increasing cell density (Fig. 1). Under these conditions, the specific activity of the isocitratase decreased by 50 per cent in each cell generation, indicating that the apparent loss of enzyme activity was not due to destruction of the enzyme, but to 'diluting out' during growth.

Cells which had been grown on succinate as sole carbon source initially contained low levels of isocitratase activity (Fig. 2). When such cells were allowed to grow in a medium containing 20 m*M* succinate and 50 m*M* acetate (Fig. 2), the specific activity of the isocitratase remained low and constant despite an increase in the cell density from 0·50 to 1·80 mgm. dry wt./ml. of medium. The plot of the logarithm of cell density against time was linear (mean generation time 1·2 hr.) and showed no evidence of diauxie. Since manometric experiments had shown that cells grown on succinate oxidize acetate without lag, and since the amount of growth observed could not have been supported by 20 m*M* succinate, it must be concluded that the cells were utilizing for growth both the added succinate and acetate simultaneously. Only after the succinate in the medium was exhausted (after a cell increase of two generations) was an increase in the isocitratase level of the cells detected. Cells grown on succinate, placed in 75 m*M* acetate growth medium (Fig. 2), grew only after a lag of approximately 2 hr. During this time, the isocitratase-level rose sharply; the specific activity of the enzyme increased from 0·20 to 1·46 μmoles of glyoxylate formed/mgm. protein/hr. before any growth was detected. By the time the cell density had increased by a third of a generation, the specific activity of 2·7, observed in acetate-grown cells (Fig. 1), had been reached, and was maintained through the subsequent logarithmic growth (mean generation time 1·4 hr.). These results indicate that: (*a*) the formation of isocitratase by *Pseudomonas ovalis* Chester varies with the growth substrates used; (*b*) high levels of isocitratase are formed when a necessity exists for net formation of C_4-compounds from acetate, but the provision of such C_4-compounds in the growth medium represses[12] isocitratase formation; (*c*) the formation of isocitratase precedes growth on acetate. This supports the role of the glyoxylate cycle[4-9] as the route for biosynthesis of cell constituents from acetate; (*d*) isocitratase formation is not induced by acetate in the presence of a C_4-compound. It is possible that it may be elicited by a fall in the intracellular concentration of a repressor[12] (such as an intermediate of the tricarboxylic acid cycle), as would occur with the provision of acetate as sole carbon and energy source.

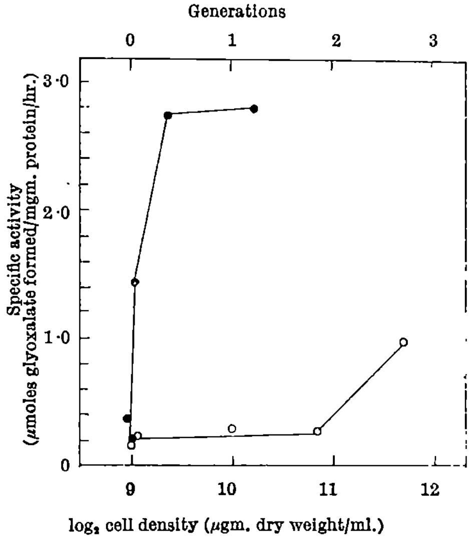

Fig. 2. Variation of specific activity of isocitratase with cell growth. Succinate-grown *Pseudomonas ovalis* Chester incubated in growth media containing 75 m*M* acetate (●—●) or 20 m*M* succinate + 50 m*M* acetate (○—○) as carbon sources

We wish to thank Sir Hans Krebs for his encouragement and interest, Prof. D. D. Woods for the gift of a culture of *Pseudomonas ovalis* Chester, Prof. Boris Magasanik (Harvard Medical School) for many stimulating discussions, Dr. H. B. Vickery (Connecticut Agricultural Experiment Station, New Haven) for a generous gift of potassium dihydrogen L_s-isocitrate, and Dr. June Lascelles for valuable help in the microbiological procedures used. This work was supported by the Rockefeller Foundation and by the Office of Scientific Research of the Air Research and Development Command, U.S. Air Force, through its European Office, under Contract No. *AF*.61(514)–1180.

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LETTERS TO THE EDITORS

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Carbon-14 Activity during the Past 5,000 Years

RECENTLY, C. Crowe[1] has attempted to demonstrate that the carbon-14 activity in the atmosphere has been subject to considerable variations during the past 5,000 years. He did this by plotting the carbon-14 data of a number of samples of historically known age. By this method a variation in the atmospheric carbon-14 activity appears as a systematic difference between the carbon-14 and the historical age.

On closer inspection the remarkable variations obtained by Crowe are seen to be due to unjustified corrections. In correlating the data of different laboratories, he assumes corrections arising from different recent carbon-14 standards, but the numerical values of these corrections are not realistic. For example, he assumes that the Heidelberg dates are all 375 yr. older, while the Stockholm dates are 525 yr. younger, than those of Groningen. It has been shown previously[2,3] that differences in the recent standards of different laboratories do indeed exist, but the deviations are nothing like so large as Crowe assumes. Laboratories using wood standards from the previous century and others using modern organic material (from about 1930–53) give different ages for the same sample because of the effect of industrial combustion. This has the consequence that modern material and a standard derived from it show a lower activity. The latter group of laboratories accordingly give dates which are too young.

When this effect was discovered by Suess[4], some laboratories already working (for example, Chicago and Groningen) kept their modern standard for the sake of simplicity and intended to ascertain the exact value of the correction before applying it. Thus the Groningen dates are about 240 yr. later than the Heidelberg dates. On the other hand, a large deviation between Stockholm and Heidelberg cannot exist because both laboratories use pre-industrial wood. This has also been established experimentally by dates (unpublished) obtained for the same specimen. It is not quite clear to us how the large corrections found by Crowe arise, but it might be possible that they come from the fact that there are only a few carbon-14 dates of the same specimen made by different laboratories and that some of these dates have large statistical errors. The comparison of such dates will give a 'correction' having a considerable chance deviation, which then will enter the further calculations as a systematic one and seriously affect the results. Indeed, the variations of activity found by Crowe arise essentially from the corrections he applied to the Heidelberg and Stockholm dates, pushing the former up and the latter down. Because of the fact that the Stockholm dates cover the age-range between 1,000 and 3,000 B.P. while the Heidelberg dates are concentrated at 2,000 years ago, a fictitious peak at 2,000 B.P. results.

In Table 1, which corresponds to Crowe's table, tentative values are listed which are to be applied in order to bring the dates of some other stations on to the Groningen scale. The difference between Groningen and Heidelberg dates is experimentally known to some extent by measurements of de Vries[2]. The other laboratories have been provisionally assumed to be equal to Groningen or Heidelberg, depending on the kind of standard they use. Deviations of 1 or at most 2 per cent in activity (up to about 150 yr. in age) are possible but not yet established and accordingly have been disregarded. Using the more realistic and much smaller corrections of Table 1, the data used by Crowe have been replotted in Fig. 1. The large systematic variations indeed vanish. It should be mentioned, however, that the scattering of the points, though much smaller than before, is somewhat larger than to be expected from the root-mean-square counting errors alone. This may be due to the fact that data have been used which do not satisfy the necessary requirements as regards purity and reliability of historical evidence.

Table 1. YEARS TO BE ADDED TO OR SUBTRACTED FROM ALL DATES TO BRING THEM ON TO THE GRONINGEN SCALE, WHICH IS NOT CORRECTED FOR THE SUESS EFFECT

University of Chicago	0
Institute of Archæology	0
Lamont Geological Observatory	−240
University of Michigan	−240
Swedish Geological Survey	−240
University of Heidelberg	−240

Tentative values are given here, the estimated root-mean-square error being ± 80 yr. For the Heidelberg value (−240) the root-mean-square error is smaller (± 40 yr.).

At this stage it can be seen, however, that genuine variations in carbon-14 activity, if present, are almost one order of magnitude smaller than those found by Crowe. In any event, plots of the kind in question will be more reliable as soon as the differences in recent standards are measured more exactly. This is at present being done by measuring standard organic material distributed by the U.S. National Bureau of Standards, Washington, and an artificial standard of higher activity distributed by the Heidelberg labora-

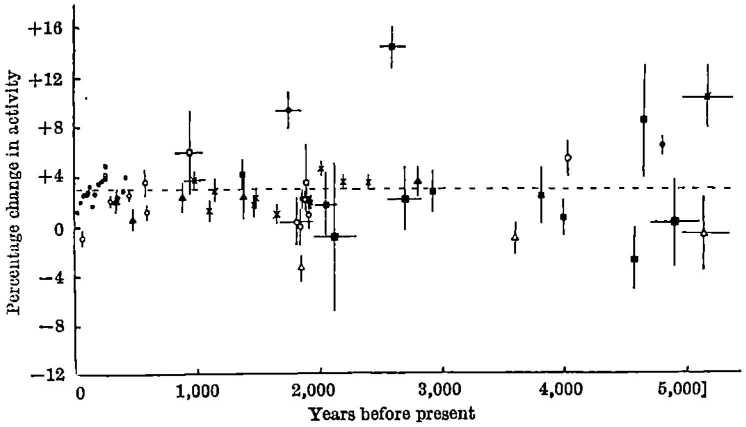

Fig. 1. Change in activity relative to that of the present versus time, taken from Crowe, but with the corrections given in our Table 1. (No attempt has been made to identify or to check the individual points; all points attributed by Crowe to each laboratory have been shifted as a whole.)

●, Groningen; ○, Heidelberg; △, Institute of Archæology; ▲, Lamont; □, Michigan; ×, Stockholm; ■, Chicago tory. Until these results are available, comparative analysis of the results from different laboratories should not be undertaken, in order to avoid premature conclusions.

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IN a recent communication, C. Crowe[1] uses published dates on samples of known age in an attempt to investigate variations of the concentration of carbon-14 in living material during the past 5,000 years. He concludes that the activity has followed a cycle with a maximum change of 10 per cent and with some evidence of a sharp peak of about 10 per cent about 2,000 years ago. His proposed curve is most striking, for the effect, if real, would imply, for example, that all 1,000-year old samples should give radiocarbon ages of more than 1,700 years, a result which has not yet been obtained in practical measurement despite the growing number of accurate measurements on tree rings and other materials of known age.

Crowe assumes in the first place that the observed difference between the radiocarbon age and the known age of a sample is due entirely to the initial carbon-14 activity of the sample being different from that of present living material. This would only be justifiable if all other errors could be shown to have been taken into account, and if the statistical error of the radiocarbon estimation were small compared with the difference between the two ages. This is manifestly not so. Laboratories have differed to some extent in the past in dealing with the errors associated with radiocarbon dating, at first taking into account only the statistical errors of the radioactivity measurements; more recently, as other contributory factors have been discovered (for example, isotopic fractionation effects) these have been taken into account or eliminated when the necessary ancilliary instrumentation was available. Errors arising from the history of the sample before it enters the laboratory or from the lapse of time between the death of the sample and the event being dated are not included, although it is recognized that these effects, which are not amenable to mathematical treatment, may on occasion assume significant proportions compared with the statistical errors.

Secondly, Crowe attempts to eliminate systematic errors by comparing the ages obtained in the cases where laboratories have dated the same sample. This again is open to grave objection on the grounds that there are so few published examples available for such comparisons; no sample is common to all the laboratories mentioned, and in practically all cases the statistical errors are large compared with the observed differences, and thus it is very difficult to understand how his Table 1 was compiled. The only accurate approach to this problem of the elimination of systematic errors is that which is taking place at present and is being sponsored by Dr. K. O. Münnich of Heidelberg, in which all laboratories engaged in radiocarbon research are being asked to make extended measurements on the same homogeneous sample so that statistical and other errors are reduced to a very small value compared with the normal dating error.

Crowe's Table 1 is thus valueless on the above grounds alone, apart from the fact that one finds it difficult, if not impossible, to relate the values he quotes and the estimated error of ± 100 years with the available figures in the publications cited by him.

It is doubly important that the accuracy and validity of these corrections should not be allowed to go unquestioned. In the first place, one must at least attempt to prevent their use by the unsuspecting archæologist, and secondly, it is necessary to point out that Crowe's conclusions regarding the large cyclic variations in carbon-14 activity during the past 5,000 years depend almost entirely on the use of these corrections. Thus, the large depression in the trend line in the range of 1,000–2,300 years is due in the main to the influence of a group of Lamont and Stockholm samples which would occupy a much higher position nearer to the zero line were it not for the very large corrections applied to them by Crowe. Similarly, the evidence of a sharp peak at about 2,000 years seems to rest mainly on the large correction applied to the Heidelberg dates.

A more important point is that de Vries[2] has recently shown that the 'modern' standard in use in Groningen is 3 per cent lower in carbon-14 activity than the average for German trees and that consequently all Gröningen dates are in fact about 240 years too young. Crowe would have us believe that Lamont and Michigan dates are all 400 years younger, and Stockholm dates 525 years younger, than Groningen dates, and that therefore corrections of some 700 and 825 years respectively are required to convert results from these laboratories into calendar years. It is unlikely, to say the least, that three laboratories could be set up independently of each other and pass through the necessary proving and checking phases without detecting discrepancies of this magnitude.

Variations of carbon-14 activity during the past are clearly of importance to radiocarbon dating. It is known that they exist, but certainly at a lower order of magnitude than is implied by Crowe's calculations. The accurate approach to the problem of their evaluation is clearly an extension of the work of Münnich[3] and de Vries[2].

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A 'Solid-Image' Microscope

For many purposes, such as tracing networks of neural structure in the brain, a normal microscope has the serious limitation that only a thin layer of the specimen can be studied at one time, owing to the limited depth of focus of microscope objectives. When a thin section is examined, only those structures which happen to lie in the plane of the section can be observed. This plane may be confused by such objects as fibres coming away from or toward the plane of the section. A microscope which gave a large depth of field, and which presented the image as a solid in a luminous block in which the structures could be observed in depth would have important advantages over existing optical microscopes. We have designed and constructed a primitive prototype of an instrument giving such a 'solid image'. It is possible to observe this from any position and to see the structures with appropriate parallax.

The instrument involves two processes. (1) The focal plane of the objective is effectively made to 'scan' up and down through the depth of the section. In the prototype instrument, this occurs at a rate of 50 double scans/sec. The slide is mounted on a steel fork tuned to 50 c./s. which is driven by a polarized solenoid energized by a 50 c./s. sine wave. Thus the slide is carried up and down through the focal plane of the objective 50 times/sec. (2) The image is projected on to a screen mounted on a second tuned fork which vibrates at the same rate and in the same phase as the slide carrying the specimen.

Scanning serves to extract the information in depth from the specimen; the second process reconstitutes it in depth, giving a 'solid image' in the space swept by the screen. Its frequency of vibration is greater than the fusion frequency for the eye, so that little or no flicker is observed.

As the instrument stands at present, the resolution and contrast leave much to be desired. A test slide of human hair does, however, give a fairly satisfactory 'solid image' in which the positions of the hairs may be seen in depth. These positions change as the observer changes his viewing position. If the objective is brought farther from, or closer to, the slide the image of the test hairs moves through the luminous cube in a convincing manner. So far, magnifications greater than 100 have not been attempted, and the greatest useful magnification is only about 20.

We hope to produce an improved version, using the same basic principles but perhaps abandoning the physical screen in favour of shifting the virtual image of viewing lenses. The tuned forks may be replaced by some more precise system for obtaining the 'scanning' oscillatory movements. We intend to modulate the light intensity in order to increase the illumination inside the image. At present the front and back are brighter than the middle, because the velocity of the screen is greater at the centre of its sweep.

It is hoped that an instrument might be developed along these lines which will be useful for biological and other research purposes.

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Evidence for $^6_2$He 'Clusters' in Nuclei

The well-known 'α-particle' model of the nucleus, whereby certain low-A nuclei are considered as consisting of groups of α-particles, has recently received a new impetus as a result of work by Wildermuth and Kanellopoulos[1] on the 'cluster model' of nuclei. These authors have presented a formal treatment of the behaviour of 'cluster states' and illustrated it with particular reference to the nucleus $^8_4$Be considered as two α-particle clusters. At the same time they have pointed out that clusters other than $^4_2$He might be present, and in fact suggested that stable closed shells such as those with neutron numbers, N, of 50 and 82, could be considered as large clusters. The question now arises as to which clusters are in fact suitable representations of particular nucleonic configurations, and the purpose of this communication is to present evidence in this connexion.

This evidence is obtained from a simple study of the neutron numbers, N, and atomic numbers, Z, of stable nuclei. If clusters are in fact entities inside the nucleus, one would expect the $(N - Z)$ systematics of stable nuclei to show a tendency for stable nuclei to be separated from each other by the subnuclear clusters. That such tendencies do in fact exist can be seen from the published work of one of us[2,3], and we present here further evidence by way of illustration. Fig. 1 is an $(N - Z)$ versus Z diagram on which the stable even-Z odd-N nuclides have been plotted. The following features emerge very clearly: (*a*) In the low-Z region the stable nuclides are separated from each other by steps of $^4_2$He. (*b*) For higher-Z (44–56) the separation is in steps of $^6_2$He and not $^4_2$He. (*c*) The sequences are interrupted by the 'magic numbers'.

It should be mentioned that the region Z 16–44 has been omitted in order to preserve clarity in presentation. In most of this region separations of both $^4_2$He and $^6_2$He appear—it may therefore be regarded as some sort of intermediate region.

If now the $^4_2$He steps in the low-Z region are taken as evidence of the presence of $^4_2$He clusters in low-mass nuclei (as indeed seems reasonable), then it appears likely that $^6_2$He clusters are present in certain nuclei of higher mass. The same effect obtains, although not so strikingly and with less clarity, if one plots stable odd–even or even–odd nuclides (see, for example, ref. 3, Fig. 3, and ref. 2, Fig. 19).

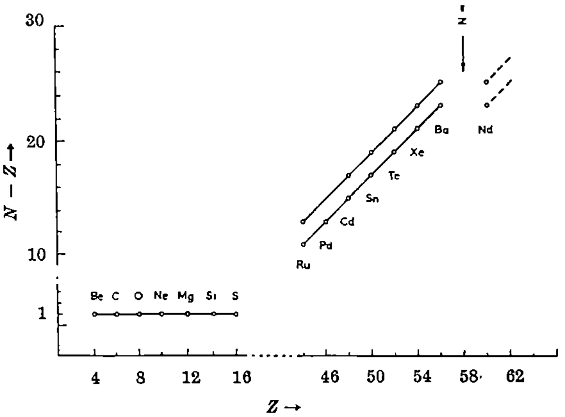

Fig. 1. $(N–Z)$ vs. Z diagram of stable even-Z, odd-N nuclides. The 'missing' nuclide $^{107}_{46}$Pd is very long lived with a half-life of 7×10^6 years

The evidence can be summarized as follows: (*a*) α-particle clusters appear to exist in the low-Z nuclei ($Z \leqslant 16$); (*b*) most of the region Z 16 to Z 44 appears to be a transitional region where the cluster can be either ${}^4_2$He or ${}^6_2$He; (*c*) from Z 44 to 56, ${}^6_2$He clusters appear to exist; (*d*) it seems likely that 'magic numbers' of protons or neutrons act as large clusters.

On this basis, then, one can (for some purposes, in any event) consider nuclei as consisting largely of 'closed shell' clusters plus one or more (seven appears to be a maximum number) smaller clusters of either ${}^4_2$He or ${}^6_2$He. If this is correct, it is, of course, most interesting to note that a cluster need not necessarily be an entity which is stable in itself (${}^6_2$He is unstable with a half-life of 0·8 sec.). A rough parallel to this situation exists in the neutron; although the neutron is itself an unstable particle, it can apparently be considered to exist as an entity in nuclei.

The question of neutron excess should also be mentioned. ${}^4_2$He has, of course, zero neutron excess, whereas ${}^6_2$He has $(N - Z)$ equal to 2. The transition from ${}^4_2$He to ${}^6_2$He clusters is therefore probably necessary in order to provide an adequate neutron excess to balance the Coulomb repulsion at higher Z. It should be noted that the discontinuities at the shell numbers always result in a reduction in neutron excess; ${}^6_2$He clusters evidently provide rather too much neutron excess.

In the region $Z > 60$, ${}^6_2$He-type regularities are also present, and several additional points of interest arise. These will be included in a more complete discussion (at present in preparation) of the cluster regularities observable in stable-nuclide systematics. At the same time, an effort is being made to investigate whether other nuclear properties exhibit ${}^6_2$He cluster effects in the appropriate regions of atomic weight.

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Extra Streaks in the X-ray Diffraction Pattern of Vanadium Single Crystals

Well-exposed Laue and oscillation photographs of vanadium single crystals show several streaks which can be easily distinguished from the Laue and Bragg spots and also from the diffuse areas of thermal scattering. Most of the following observations were made on specimens having at least one fairly bright (100) cleavage face of area 12–30 mm.^{2}. The specimens were electropolished.

The lattice parameter was derived by two independent measurements. (1) Powder photographs taken with a crushed single crystal using copper $K\alpha$ radiation and a 19-cm. Unicam powder camera. This method gave $a = 3{\cdot}036 \pm 0{\cdot}002$ A. (2) The separation of 110 Kossel lines on the single crystal photographs. This method gave $a = 3{\cdot}035 \pm 0{\cdot}001$ A. Both values agree well with the precision measurements of Neuburger[1] on high-purity oxygen-free vanadium powder, who found $a = 3{\cdot}0338 \pm 0{\cdot}0003$ A. at 25° C.

The Laue and oscillation photographs were taken with copper $K\alpha$ radiation using a Unicam single-crystal goniometer fitted with a quarter-cylinder camera (radius 114·6 mm.) and a modified version of the half-cylinder camera (radius 57·3 mm.). The latter was capable of covering the angular range from $\theta = 0°$ to 77° along the equator. Collimators of diameter ½ and ¼ mm. respectively were used. Ilford *G* X-ray film in a light-tight cellulose triacetate envelope was used. The envelope was covered with a nickel foil 0·020 mm. thick which served as a β-filter and also as an absorber of the fluorescent radiation generated in the specimen.

Powder photographs show nothing but fine continuous lines which may all be interpreted in terms of the body-centred cubic vanadium structure. The extra streaks (shown by arrows in Figs. 1,*a* and *b*) look similar to powder lines with strong preferred orientation. As the angle of incidence of the X-rays varies, the diffraction angles of the streaks remain constant, but their position along the 'powder lines' and their intensity change continuously. The intensity reaches its maximum near the centre of the angular range of incidence in which the streak is observable. This range of observability is 5°–6° for most streaks. For this reason the extra streaks on a Laue photograph and on an oscillation photograph taken around that particular stationary setting are similar (see Figs. 1,*a* and *b*). The streaks can thus be represented in reciprocal space by segments of concentric spherical shells around the origin of the reciprocal lattice. These segments subtend an angle of 5°–6° at the centre of the reflecting sphere and have maxima of intensity at their centres. Stationary-crystal photographs were taken in which the glancing angle of incidence of the X-rays on the (100) face was varied from 1° to 50°. In this angular range ten spherical shells were found and the radius of any given shell was the same for all specimens. The number of observed segments varied from one shell to another but on any particular shell it was the same for most of the specimens. One specimen, however, was found which showed a higher number of segments on some of its shells than did the other specimens. This particular crystal also behaved differently in another respect. For most specimens the arrangement of the segments on the shells conformed to the cubic symmetry of the whole crystal but the exceptional specimen showed a lower symmetry. This is illustrated by Fig. 1,*c*, which shows the extra streaks due to this specimen under the same conditions as for the usual specimens which gave Fig. 1,*a*. Fig. 1,*c* shows

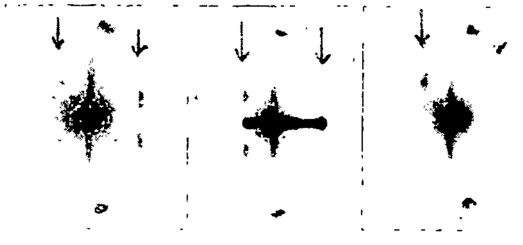
(*a*) (*b*) (*c*)

Fig. 1. (*a*) Laue photograph taken at the 200 Bragg reflexion position with pairs of extra streaks on both sides of the Laue spot. (*b*) 5° oscillation photograph taken around the setting of Fig. 1,*a*. The extra streaks show no lateral shift. (*c*) Same as 1,*a*, but taken with the crystal which showed a greater number of extra streaks (see right-hand group). This photograph shows a horizontal plane of symmetry passing through the Laue spot for the positions, but not the intensities, of the extra streaks the extra streaks in the same positions but the intensities are different from those of Fig. 1,*a*.

A detailed study of the structural implications of the above findings and their possible interpretation is in progress, and the results will be published elsewhere.

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Crystal Structure and Photoconductivity of Cæsium Plumbohalides

Wells[1] and his collaborators have shown that crystals of the general compositions $CsPbX_3$ with X = Cl, Br or I, and Cs_4PbX_6 with X = Cl or Br, may be prepared from aqueous solutions. I have investigated the structures of these crystals and also prepared a few more. I have found[2] that $CsPbCl_3$ and $CsPbBr_3$ have the perovskite structure. At room temperature they are tetragonally or monoclinically distorted. Both of them, however, show transition to pure cubic perovskite structure, at 47° C. and 130° C. respectively and with cell dimensions $a = 5\cdot605$ A. for $CsPbCl_3$, $a = 5\cdot874$ A. for $CsPbBr_3$. Whereas no extra or forbidden X-ray reflexions can be observed above these transition temperatures, $CsPbBr_3$ below 130° C.—and presumably also $CsPbCl_3$ below 47° C.—exhibit a new structure corresponding to a doubling of the cell dimensions. The transitions are likely to be of second order as $\Delta V = 0$ within the limits of accuracy of my measurements.

The $CsPbI_3$ crystals from aqueous solution are orthorhombic with space group No. 62 *Pnma* and $a = 4\cdot795$ A., $b = 10\cdot45_7$ A., $c = 17\cdot76$ A. The X-ray analysis yields all the atomic positions and interatomic distances: the lead atom is surrounded octahedrally by six iodine atoms at distances 3·01–3·42 A., and nine iodine atoms form distorted ditrigonal pyramids around each cæsium atom at distances of 3·87–4·19 A. The lead and iodine ions form chains of polynuclear complex ions parallel to the *a*-axis of the crystal. On heating these crystals to 305–308° C. they undergo a phase change and the colour changes from yellow to black. This black form which may also be obtained by melting cæsium iodide and plumbous iodide together in the correct stoichiometric proportion is rather unstable, and hence had to be investigated on a Geiger–Müller diffractometer. From its powder diagram it appears to have a monoclinically distorted perovskite structure ($a = b = 6\cdot15$ A., $c = 6\cdot23$ A., $\beta = 88\cdot15°$). It shows the same kind of superstructure as $CsPbBr_3$.

It is interesting to note that the above-mentioned crystals with perovskite structure are intensely coloured: $CsPbCl_3$ is pale yellow, $CsPbBr_3$ is orange and $CsPbI_3$ black, whereas crystals of the type Cs_4PbX_6 with X = Cl, Br or I are colourless. From this peculiarity one might guess that the former crystals also have special electrical properties. With a very crude apparatus we have found that the coloured $CsPbX_3$-crystals with perovskite structure are photoconductive, $CsPbCl_3$ having its maximum spectral sensitivity in the violet, $CsPbBr_3$ in the blue to green region and $CsPbI_3$ in the red region, that is, the spectral region which is complementary to the colour of the crystals.

A detailed account of this work will be published elsewhere.

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Nuclear Magnetic Resonance in β-Brass

Bloembergen and Rowland[1] have shown that the addition of small amounts of zinc to copper reduces the intensity of resonance in the resulting alloy so that the line becomes unobservable when the zinc content reaches approximately 25 per cent. They explained this effect in terms of quadrupole broadening and pointed out that, in ordered structures with cubic symmetry, quadrupole broadening should be absent and a line would be expected. However, they found no resonance in a β-brass of about 50/50 composition (quoted by Bridgman[2] as 47·3 per cent zinc) and they suggested that the ordering was not complete.

Experiments in this laboratory have shown that there is a strong copper-63 resonance in a β-brass containing 48·33 per cent zinc by weight. The specimens were prepared by filing at room temperature and sieving through a 120-mesh sieve, annealing for 2 hr. at 450° C. in an argon atmosphere, and then slowly cooling to room temperature. The detecting apparatus was a conventional Pound–Knight–Watkins type of spectrometer operating at approximately 5·96 Mc./s. and a 'Varian' 12-in. electromagnet set at approximately 5,250 oersted. All experiments were done at room temperature.

The main features of the resonance line for the annealed powder are as follows: (1) The line is symmetrical with the centre located 5·2 kc./s. below that for well-annealed copper of 99·98 per cent purity under the same conditions. This means that the Knight shift ($\Delta H/H$) for copper in a well-ordered β-brass structure is approximately 0·14 per cent, as compared with 0·23 per cent for pure copper. (2) The integrated area under the absorption line is one-sixth of the area under a line obtained from a specimen of pure copper containing the same number of copper nuclei. (3) The line for β-brass is appreciably narrower than that for pure copper, this smaller dipole broadening being consistent with the fact that the next nearest copper neighbours are farther away than they are in pure copper. (4) The line can be eliminated almost completely by plastic deformation. This was shown by testing a specimen immediately after filing and sieving.

The detailed effects of deformation, heat treatment, and variation of composition have been studied and will be described elsewhere.

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A New Phase in a Complex Alloy Steel

DURING investigations into the age-hardening of a steel containing 12 per cent chromium, 4 per cent nickel, 3 per cent manganese and 2·5 per cent silicon, a phase not previously reported was extracted electrolytically. This new constituent has been arbitrarily designated *S* phase.

Table 1. *d* SPACINGS OF *S* PHASE. LATTICE PARAMETER 11·50 A.

Intensity	*d* observed	*h,k,l*	*d* calculated
VVF	2·784	4,0,0	2·787
F	2·278	4,2,2	2·276
S	2·143	5,1,1 ; 3,3,3	2·144
VS	1·970	4,4,0	1·971
M	1·882	5,3,1	1·885
VF	1·858	6,0,0 ; 4,4,2	1·858
F	1·763	6,2,0	1·763
F	1·701	5,3,3	1·700
VF	1·680	6,2,2	1·681
VVF	1·487	6,4,2	1·490
VF	1·452	7,3,1 ; 5,5,3	1·452
F	1·315	8,2,2 ; 6,6,0	1·314
F	1·288	7,5,1 ; 5,5,5	1·287
M	1·224	9,1,1 ; 7,5,3	1·224
VVF	1·216	8,4,2	1·216
VVF	1·170	9,3,1	1·169
F	1·139	8,4,4	1·138
M	1·122	9,3,3 ; 7,7,1 ; 7,5,5	1·120
VF	1·079	9,5,1 ; 7,7,3	1·078
VF	0·9855	8,8,0	0·9856
F	0·9750	11,3,1 ; 9,7,1 ; 9,5,5	0·9741

Table 2

Element	Si	Ni	Mn	Cr	Fe
Atomic (per cent)	23·8	44·5	7·6	15·1	9·1

X-ray diffraction patterns and semi-quantitative chemical analysis revealed the structure and composition of *S* phase. The interplanar spacings are shown in Table 1. It has been indexed as a face-centred cubic lattice with parameter $a = 11{\cdot}50$ A. Table 2 gives the chemical composition of *S* phase. The values obtained suggest an approximate formula M_3Si, where *M* is largely nickel.

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A Method for Determination of Particle Penetration Depths in a Filter

A DETAILED knowledge of how particles penetrate a filter when an aerosol is filtered can give a good deal of information about properties of both filter and particles. In this communication, a simple method for the determination of particle penetration is described.

An aerosol, consisting of radioactive solid particles 0–2μ in diameter, was filtered at an air velocity of 100 cm./sec. through a glass-fibre paper (L.O.F. Glass Fibre Co., 475 Code 106 *AAA* glass, 0·2 mm. thick, 58 gm./m.², 'volume-surface' fibre diameter[1] 0·6μ).

225 cm.² of this filter was pressed against a gummed cellulose-acetate film, with the air-entry side of the filter downmost. On removal, a thin layer of glass fibre was left on the sticky surface. The process was repeated until the whole filter was divided into twenty such layers each about 10μ thick. It was difficult to obtain layers of equal thickness, especially at the end of the process, when the sticky films now and then tore thicker pieces from the remaining glass-paper. The weights of the layers (after ashing of the sticky film) were found to vary between 30 and 80 mgm., the average being 60 mgm.

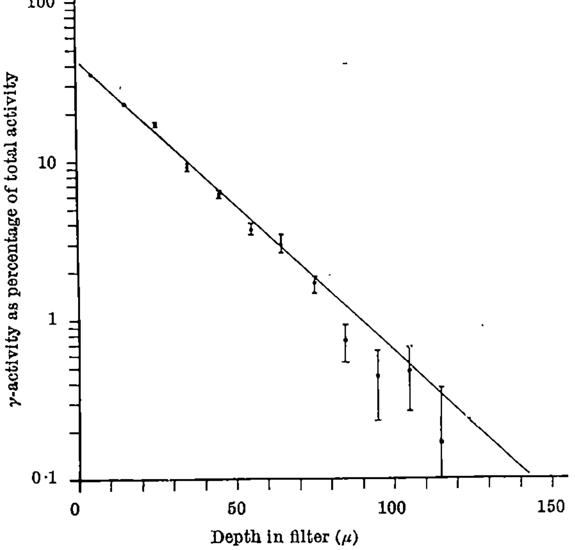

Fig. 1. γ-activity of filter layers as a function of depth in filter

Each layer was radioautographed and the γ-activity measured with a scintillation counter. The autoradiograph spots were counted and divided into five size classes, which were attributed to corresponding classes of radioactive strength by calibrating with active particles of known strength. The activity of the different particles being known, their sizes could thus be approximately determined.

The results are given in Figs. 1 and 2. An interesting phenomenon, which, so far as I know, has not

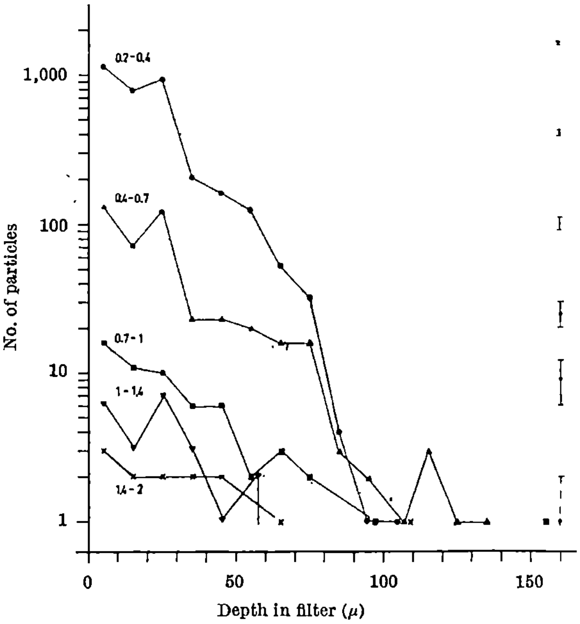

Fig. 2. Number of particles in filter layers as a function of depth in filter. The figures on the left are the range of particle diameters in μ. Statistical errors are given on the right

been dealt with before, is that the bigger particles are more likely to penetrate deep into the filter than the smaller ones, indicating that they are shot into the filter by the fast air stream, pushing the fibres out of the way and penetrating deeper the more momentum they have, instead of being stopped by the first filter fibre they meet.

On account of the wide variations in the weights of the layers mentioned above, it might have been expected that the plot of activity against depth (Fig. 1) would be more irregular. However, the excess weights of the heavier layers are mainly due to material from parts of the filter with lower activity. The error in the activity of a layer will therefore seldom be positive and, in fact, it is likely to be more negative the deeper the layer. This tendency of the error may be expected to give the graph a steeper slope than it ought to have. The method may possibly be improved in this respect, perhaps by using laminated filters.

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Comparison of Measured and Computed Values of the Rapid Fading-Rate of Ultra High-Frequency Signals reflected from the Moon

DURING August 1957, a bistatic moon reflexion experiment was carried out between South Dartmouth, Massachusetts (41·5395° N., 70·9512° W.), and Alpha, Maryland (39·3224° N., 76·9258° W.). The continuous-wave transmitter fed approximately 40 kW. of power, at a frequency of 412·85 Mc./s., into a horizontally polarized feed mounted in a 60-ft. diameter parabolic antenna. The antenna was movable in azimuth and elevation. The receiving system at Alpha used a dual-polarization feed in a 28-ft. diameter parabolic antenna, which was free to move in azimuth and elevation.

Two identical receiving systems were used, with band-widths of 50 c./s. With front end noise figures of approximately 5 db., maximum signal to noise ratios of approximately 25 db. were obtained. A common local oscillator was varied in frequency so that the changing Doppler frequency of the moon-reflected signal could be followed.

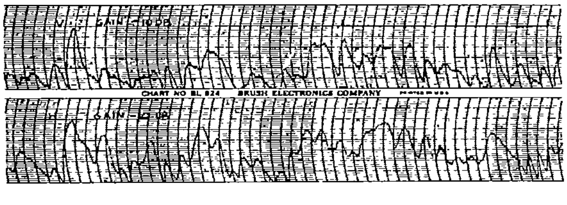

Fig. 1. Moon signal: examples of fading-rates. 1538 E.S.T. Top, vertical; bottom, horizontal. Scale, 10 sec.

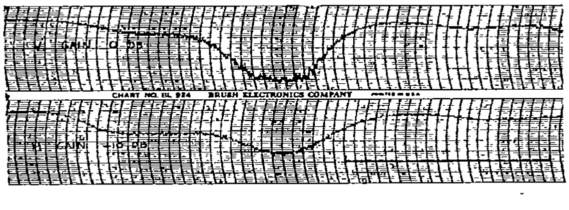

Fig. 2. Moon signal: examples of fading-rates. 0854 E.S.T. Top, vertical; bottom, horizontal. Scale 10 sec.

The system was operated from moonrise to moonset each day during August 6–August 29, 1957, apart from interruptions caused by equipment difficulties. The usual effects due to Faraday rotation were noted; that is, the individual signal-levels varied with periods of hours while the total received signal power-level remained quite constant, apart from the slow change due to the varying Earth–Moon distance.

The rapid fading-rate of the signals detected was observed to vary during the course of the experiment, from a maximum of several cycles per second to minimum rates at which the signal-levels remained almost constant for several minutes. Fig. 1 shows a typical fading-rate (with a detector time constant of 0·015 sec.), while Fig. 2 shows a very low fading-rate period.

It seemed reasonable to assume that the total effective libration rate of the Moon had a strong influence in producing these varying fading-rates[1]. For example, if the Moon is assumed to possess just three small reflecting regions, a central one and two others symmetrically located with respect to the centre, then a continuous wave signal would be reflected with small Doppler side-bands, in addition to the over-all Doppler shift. After detection, the side-bands would show up as effective 'fading' of the signal. Now in practice many portions of the Moon are effective in giving rise to appreciable reflexions, although a precise description of the mechanism is not possible. However, if on the Moon's surface one considers a circle drawn the radius of which is a given fraction of the full radius of the Moon, then one can examine all points on this circle and determine the maximum magnitude of the Doppler spread. By comparing this number with the observed fading-rate (defined in some rather arbitrary but consistent manner) it is then possible to determine whether or not the variations in fading-rate of the received signals are due primarily to a Doppler spread caused by libration.

A programme has been written for the *IBM* 704 computer which yields the over-all Doppler shift and libration-rate. Further trigonometry then enables these data to be converted into Doppler spread. Two subdivisions were made in the programme. (1) First-order differences only were retained, leading to a result which was normalized with respect to the Moon's radius. (2) Further refinements were introduced, leading to computations which could not be normalized, but which had to be carried out for a number of values of fractional radii of the Moon.

Results obtained from (1) are shown in Figs. 3 and 4, with a figure of 0·67 used for the fractional radius of the Moon. That is, the computed 'fading-rates' are actually computed maximum Doppler spreads on a circle of two-thirds the Moon's radius. The observed fading-rates were obtained by counting maxima of the detected signal over an interval of a minute or so at each period.

In general, results from (2) above were not significantly different from results obtained from (1). At periods of very low fading-rate the computed values from both (1) and (2) showed spreads of the order of 0·01 cycle per second, while the observed fading-rates often were considerably less than this.

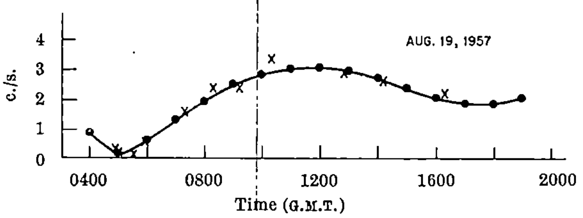

Fig. 3. Fading-rate of signal reflected from the Moon. ●, Computed ; ×, experimental

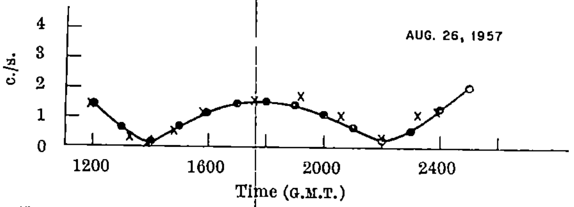

Fig. 4. Fading-rate of signal reflected from the Moon. ●, Computed ; ×, experimental

It appears that the limiting factor in the accuracy of the computation is probably the somewhat abbreviated values of selenographic latitude and longitude, published in the American Ephemeris and Nautical Almanac. However, apart from the periods of very low fading-rate, excellent agreement was obtained between measured and computed values. Hence, for frequencies in the ultra high-frequency band, it appears that the rapid fading of a signal reflected from the Moon can be predicted in some detail from dynamical considerations. Thus other effects, for example, those which might be due to the ionosphere, must be correspondingly limited. Any extreme effect, such as that which might occur during auroral activity, might show up experimentally as a noticeable departure from the computed values.

It is a pleasure to acknowledge the assistance of the staff of the Massachusetts Institute of Technology Round Hill Field Station at South Dartmouth, Massachusetts, and many others in the Lincoln Laboratory who took part in the experiment.

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Possible Causes of Geomagnetic Fluctuations having a Six-Second Period

Geomagnetic fluctuations of two different types in the frequency-range 0·1–30 c./s. have recently been reported by Duffus *et al.*[1]. Fig. 2 of their communication shows that one of these types closely resembles two other naturally occurring oscillations, and has a period (about 6 sec.) of the same order as the latter. These two naturally occurring (and probably associated) oscillations are microseisms and microbaroms, and one or the other of them may be the cause of the observed magnetic oscillations.

If the pick-up loop used for recording the variations of the magnetic field was so mounted that the microseismic oscillations of the Earth's crust could have caused rotation of the loop with respect to the Earth's permanent magnetic field, it is possible that currents having the same frequency as the microseisms could have been induced in the loop. Because of the very large wave-lengths of the seismic oscillations, however, this explanation seems somewhat improbable. (The entire loop would tend to move up and down as a unit rather than rotate.)

It seems somewhat more probable that the observed magnetic effects result from atmospheric oscillations of the same period. These oscillations were first observed by Benioff and Gutenberg[2,3], and were named by them microbaroms. Microbaroms have also been studied by other workers[4–7]. It has been pointed out by Daniels[6] that the particle amplitude of microbaroms would be much greater at ionospheric levels than at the Earth's surface, the amplification being of the order of 1,800 at an altitude of 120 km. Particle velocities of the order of 40 cm. sec.$^{-1}$ would therefore occur at this altitude if the pressure amplitude at the Earth's surface were 1 dyne cm.$^{-2}$ (a value which is occasionally observed).

A detailed theory explaining how an atmospheric oscillation having such a period and velocity can give rise to a magnetic fluctuation still remains to be formulated. The relationship between the magnetic and microbarometric oscillations could, however, be studied experimentally by making simultaneous observations of the two phenomena. A similar study was made by Saxer[7] for the purpose of establishing a correlation between microbaroms, microseisms and ocean waves. One difficulty connected with such a study is that the microbarometric pressure variations are so small that they are often masked by pressure fluctuations due to atmospheric turbulence. This interference, however, could be minimized by using an infra-sonic line microphone of the type invented by Daniels[8] with which an improvement in the signal-to-wind-noise ratio of as much as 20 db. can be achieved at frequencies in the region of interest.

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Zeta Potential and Sedimentation Behaviour in Flocculated Cane Sugar Juice

The stability of an aqueous suspension is reflected in both sedimentation-rate and sedimentation-volume[1,2]. In a stable system, settling of the single particles is slow, but they remain free to move independently of each other into positions of close packing in the sediment. In the unstable and flocculated system, settling of the particle aggregates is rapid, but their packing in the sediment is now of a random nature and the sedimentation volume is large. When the flocculation of a stable suspension is brought about by a decrease in zeta potential, both settling-rate and sedimentation-volume increase as ζ approaches zero.

When flocculation of the suspension is not brought about by a change in ζ, the particles within a floc still carry their original electrostatic charge. The question then arises: To what extent can a change in ζ now affect the sedimentation behaviour of the flocs ?

Cane juice is a protein-stabilized suspension of waxy and other particles[3] which may be flocculated by the precipitation *in situ* of calcium phosphate; in this case complete destabilization occurs with no appreciable change in ζ. The flocs are composed of clusters of particles bound together in a matrix of the inorganic precipitate[4] and they settle to give a mud volume approximately twenty-five times the total volume of particles and precipitated material. It is therefore of interest to study the effect of a decrease in ζ upon the sedimentation of this unstable system in which flocculation is effectively independent of ζ.

Fig. 1 shows the effects on sedimentation and zeta potential of two detergents, cetyltrimethylammonium bromide and sodium laurylsulphate. The experimental method used to assess sedimentation behaviour has been fully described in another paper[5], where the calculation and significance of the settling constant K (the velocity of the interface when the volume of mud is twice that after infinite settling time) and the sedimentation volume H_∞ (the volume percentage of mud after infinite settling time) are fully discussed. Determination of electrophoretic mobilities was carried out by a microelectrophoresis technique fully described in another paper[6]. Mobilities could not be measured directly on settling-tube contents, but were measured on samples of juice diluted twenty-fold with 0·01 M potassium chloride in the required concentration of detergent. Since the sedimentation behaviour curves are symmetrical about the reversal of charge concentration of cetyltrimethylammonium bromide (0·37 mM) determined on these diluted samples it must be concluded that the same reversal of charge concentration would have been found in the settling-tube contents. Consistent with this observation, it may be noted that in oil/water emulsions stabilized by bovine serum albumin the reversal of charge concentration of myristyltrimethylammonium bromide is 0·36 mM and this value is independent of concentration of both total protein and oil drops (Bennett, M. C., and Haydon, D. A., unpublished work).

The outstanding feature of the sedimentation behaviour lies in the fact that there is a maximum in settling-rate at the reversal of charge point and that this is accompanied by a minimum in sedimentation-volume. The occurrence of a minimum in sedimentation-volume shows that the decrease in ζ has not led to an increase in particle aggregation, and it follows that the maximum in settling-rate must be attributed to a more closely packed arrangement of particles within the floc itself. On the basis of the floc structure described above it may therefore be suggested that mutual electrostatic repulsion between individual particles in a floc tends to maintain a less closely packed spatial arrangement than might be assumed by uncharged particles. A decrease in particle charge should therefore lead to a more compact floc structure, which must be accompanied by an increase in settling-rate and a decrease in sedimentation-volume.

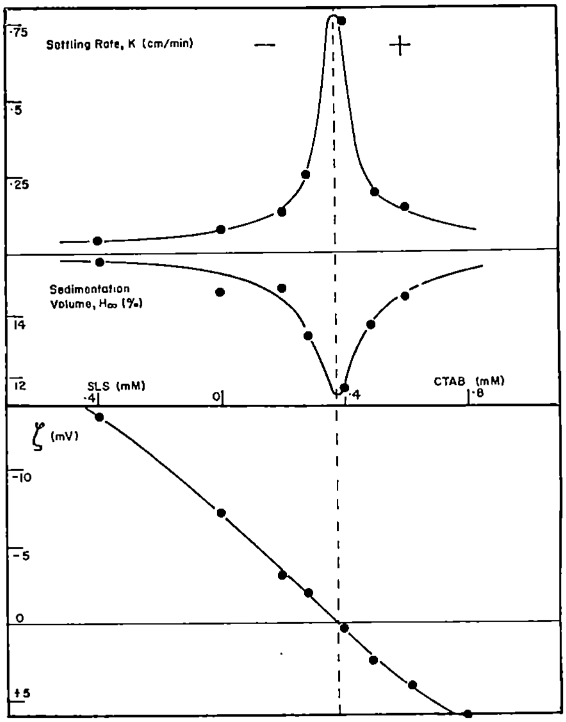

Fig. 1. Settling rate, sedimentation volume and zeta potential against concentration of cetyltrimethylammonium bromide (CTAB) and sodium laurylsulphate (SLS)

In similar studies on other cane juices it has been possible to demonstrate marked deviations from the behaviour described here. In one case, the H_∞ curve showed a slight maximum at the reversal of charge point; it was shown that this juice was abnormally stable towards calcium phosphate precipitation so that a reduction in zeta potential was accompanied by an appreciable decrease in stability and an improvement in flocculation. In some juices, the flocculated system was found to be completely insensitive to the action of detergents, while in others the reversal of charge concentration of cetyltrimethylammonium bromide was found to have increased to as much as 0·70 mM. In every case it is believed that these deviations are associated with the presence at the particle surface of layers of various polysaccharide materials; the evidence is discussed elsewhere[6].

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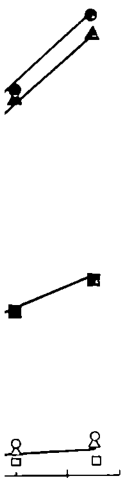

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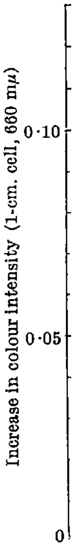

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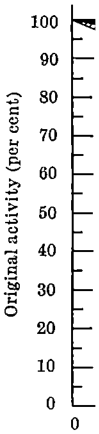

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Russell Anderson, Mrs. Mary Grebner and Miss Patricia Orlic, for technical assistance, and to the U.S. Public Health Service for grant No. 1625.

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Effect of γ-Aminobutyryl-Choline upon the Electrical Activity of the Cerebral Cortex

RECENTLY, Kuriaki[1] succeeded in synthesizing γ-aminobutyryl-choline and obtained some evidence of its presence in the brain. In the present study we have observed its effects on the electrical activity of the cerebral cortex.

Experiments were carried out on ten rabbits and a few cats under urethane anæsthesia. Evoked potentials were led off by means of a unipolar silver wire electrode with a ball tip (diam. 0·5 mm.) placed on the pial surface.

For electrical stimulation, square-wave pulses of 0·02–0·1 msec. were used. Shock artefacts were minimized by the use of an isolation transformer. Potentials were recorded by a condenser-coupled amplifier (time constant 0·5 sec.) led to a dual-beam oscilloscope.

All the test solutions were applied locally to the cortical surface with squares of filter paper approximately 2·0 mm. × 2·0 mm.

The primary sensory potential complex evoked and recorded from the surface of the sensory cortex in response to the stimulation of the contra-lateral peroneal nerve consists of an initial surface-positive potential followed by a surface-negative wave.

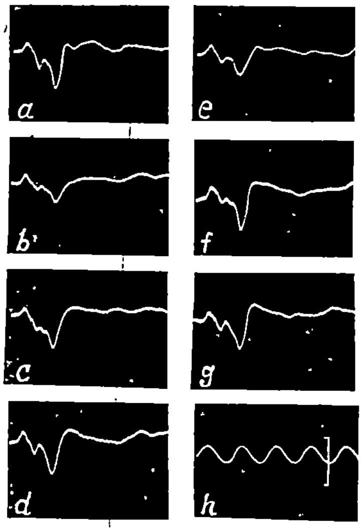

Fig. 1. Effect of γ-aminobutyryl-choline on the primary sensory potential evoked by stimulation of the contra-lateral peroneal nerve. Left-hand column: *a*, control; *b*, 30 sec. after the application of $4 \cdot 0 \times 10^{-4}$ *M* γ-aminobutyryl-choline; *c*, *d*, respectively, 30 sec. and 5 min. after the cortex was washed with Ringer solution. Right-hand column: *e*, 3 min. after $4 \cdot 0 \times 10^{-5}$ *M* γ-aminobutyryl-choline; *f*, *g*, recovery of responses 1 and 2 min. after washing off γ-aminobutyryl-choline; *h*, 50 c.p.s. The vertical bar represents 0·5 mV.

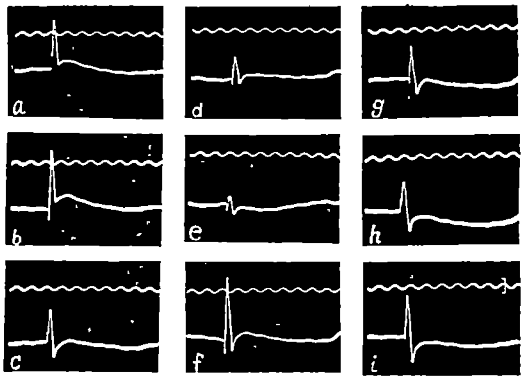

Fig. 2. Effect of γ-aminobutyryl-choline on the dendritic potential at 2 mm. distant from the stimulating electrodes in a rabbit. Records *a*, *b*, control; records *c*, *d*, *e*, 3, 4 and 6 min. after $4 \cdot 0 \times 10^{-3}$ *M* γ-aminobutyryl-choline; record *f*, 2 min. after washing off γ-aminobutyryl-choline. Response increased for some minutes. Record *g*, 16 min. after washing; record *h*, 5 min. after $4 \cdot 0 \times 10^{-4}$ *M* γ-aminobutyryl-choline; record *i*, recovery 1 min. after washing

Topical application of γ-aminobutyryl-choline to the sensory cortex resulted in rapid decreases in the surface-positive as well as surface-negative phase of the evoked potential.

The concentrations which caused appreciable depression were $4 \cdot 0 \times 10^{-5}$–$4 \cdot 0 \times 10^{-4}$ mol./l. An example is shown in Fig. 1. In addition, there was a prolongation of the surface-positive wave.

Depression of the primary sensory evoked potential occurred at once after the application. Washing the substance from the cortex resulted in rapid recovery (almost within 30 sec.) of the original wave form.

γ-Aminobutyryl-choline exhibited marked inhibitory action on the local electrical response of the cortex to direct surface stimulation. The response was led off at 2 mm. distant from the stimulating electrodes. γ-Aminobutyryl-choline was applied to the locus where the response was recorded.

With stronger stimulation, the direct cortical response consists of an initial surface-negative wave followed by a positive wave and a secondary surface-negative slow wave. γ-Aminobutyryl-choline depressed rapidly two surface-negative components, but left the surface-positive component almost unaffected for a few minutes. Using concentrations greater than $4 \cdot 0 \times 10^{-5}$ mol./l., we observed the striking inhibitory action of γ-aminobutyryl-choline on the direct cortical response.

On washing the chemical from the cortex, immediate recovery took place; though an increase in amplitude of the initial negative component beyond the original was sometimes observed in the beginning phase of the recovery. A typical example is given in Fig. 2.

The inhibitory action of γ-aminobutyryl-choline on the metrazol-convulsive spikes was compared in the same rabbits with that of γ-aminobutyric acid, the inhibitory action of which on the electrical activity of the cortex has been reported by some investigators[2,3].

γ-Aminobutyric acid could induce complete inhibition of the excitation by 10 per cent metrazol in the concentration of $1 \cdot 0$–$5 \cdot 0 \times 10^{-1}$ mol./l. On the other hand, γ-aminobutyryl-choline, at $2 \cdot 0$–$4 \cdot 0 \times 10^{-4}$ mol./l., caused complete inhibition. That is, the inhibitory strength of γ-aminobutyryl-choline was about 500–1,000 times as powerful as that of γ-aminobutyric acid.

We consider that γ-aminobutyryl-choline may be the true physiological inhibitory substance in brain. A fuller account will be reported elsewhere.

We are thankful to Prof. Kuriaki and Daiichi Seiyaku Co. for the gift of γ-aminobutyryl-choline.

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Production of Glucose by the Liver during Hyperglycæmia

The effect of hyperglycæmia on hepatic glucose output has been studied employing an isotope dilution technique. Glucose labelled with carbon-14, of the same specific activity as the blood glucose, was injected in amounts sufficient to produce hyperglycæmia. The selection of the appropriate specific activity for this glucose 'load' was made easier by a procedure in which an infusion of labelled glucose (in 'weightless' amount) was continued throughout the experiment. During such an experiment the blood glucose specific activity remains relatively constant so long as the flow of unlabelled glucose from the liver continues at a uniform rate. On the other hand, the specific activity of the blood glucose rises if the flow of unlabelled glucose from the liver stops or decreases[1]. The present technique avoids the misleading values for plasma glucose specific activity which might result from slow mixing of injected unlabelled glucose with a labelled body glucose pool[1].

In two experiments in pentobarbital anæsthetized dogs, an amount of glucose with an appropriate specific activity was injected to produce hyperglycæmia (Fig. 1). During the period of hyperglycæmia the blood glucose specific activity did not rise. This indicates that the output of unlabelled glucose by the liver continued during the period of hyperglycæmia.

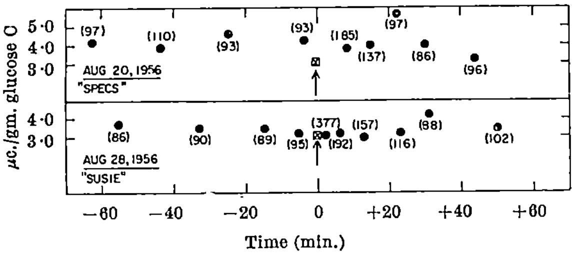

Fig. 1. Carbon-14 concentration in blood glucose before and after the injection of a glucose load and during a constant infusion of glucose-^{14}C in 'weightless' amount. The carbon-14 concentration of the glucose load, 1 ml. of 30 per cent (w/v) glucose/kgm. dog weight, is shown by the location of the × enclosed in a square at zero time (the mid-point of the load injection interval of 2–3 min. duration). Blood glucose concentrations in mgm. glucose per 100 ml. whole blood are given in parenthesis above or below each point showing carbon-14 concentration. Randomly labelled glucose-^{14}C was used in these experiments

These studies, therefore, do not support the conclusion[2,3], based on measurements of liver blood flow and differences of hepatic arteriovenous blood glucose concentration, that hyperglycæmia stops net hepatic glucose output. However, there is not necessarily a conflict between the present studies and these previous findings, since among the determinants of net hepatic glucose output are factors which are not measured by the isotope technique.

The uptake and output of glucose by the liver after a large amount of glucose is administered may involve several metabolic processes. Storage (whether in extracellular fluid, intracellular fluid or as preferentially removable end-groups of glycogen[4]) of blood glucose may occur during hyperglycæmia, followed by loss to the blood of the same glucose molecules as the blood glucose concentration returns to normal. In addition, during hyperglycæmia there may be increased utilization by the liver of circulating glucose for carbon dioxide production or for net synthesis of non-carbohydrate materials. These processes will influence the net difference between glucose entering and leaving the liver as determined by hepatic venous catheterization methods, but, there being no dilution by glucose-^{12}C, they will not be reflected in hepatic glucose production as measured by isotope dilution techniques.

The net production of new glucose molecules in the hepatic cell influences the measurement of net glucose output in catheterization studies and is thought to be almost entirely responsible for the decrease in specific activity observed in experiments employing isotopic tracer methods to determine hepatic glucose output. This process is of particular interest with regard to diabetes mellitus, because it has been implied[5] that insulin acts directly to stop hepatic glucose output during hyperglycæmia in the normal animal, whereas in the diabetic animal the absence of insulin eliminates this direct control mechanism.

It is conceivable also that an exchange of carbon-14 and carbon-12 atoms via the metabolic intermediates in the liver cell might contribute to a decrease in specific activity during isotope dilution measurements in certain circumstances. For example, an increased turnover of liver proteins during hyperglycæmia might introduce more carbon-12 atoms into the metabolic intermediates common to carbohydrate and amino-acid metabolism and simultaneously remove more carbon-14 atoms in the direction of protein synthesis. The end result would be a more rapid dilution of the circulating labelled glucose, whereas no increase in net protein degradation or net glucose production had occurred.

From the above it is concluded that the undiminished rate of dilution of labelled blood glucose during hyperglycæmia in the anæsthetized normal dog reported here must be interpreted as indicating either: (1) that the production of glucose in the hepatic cell continues during hyperglycæmia, or (2) if glucose production does cease there is a concomitant increase in an exchange process of the kind discussed above.

In previous applications of the isotope dilution technique to this question the results have been interpreted as indicating that hepatic glucose production ceases during hyperglycæmia[5,6]. In these earlier studies a glucose-^{12}C 'load' was administered after a single injection of glucose-^{14}C and consideration was not given to the slowness with which intravenously injected glucose mixes with a part (about half) of the glucose pool.

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'Karathane' : the Relative Importance of the Phenolic and Unsaturated Acid Components in Toxicity towards Certain Plant Pathogens

THE commercial acaricide and fungicide currently offered as 'Karathane' has been shown to be one of the few substitutes for sulphur for the control of powdery mildews on a number of crops. The active ingredient is stated to be 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenyl crotonate, although some of the phenol is usually present in the free state.

Rich and Horsfall[1] reported that "laboratory and greenhouse tests showed that tenacity and phytotoxicity are due to the dinitrocaprylphenyl portion of the molecule, while the fungitoxicity is due to the crotonic acid portion". It was later learned (Rich, S., private communication) that this view was based on glass-slide experiments using spores of *Stemphylium sarcinaeforme* (Cav.) Wiltsh. as test organism, a spore suspension being added to the slide cavity after drying the initial solution or suspension of test substance. Germination was not inhibited by 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenyl crotonate, 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenol or crotonic acid alone, or by a mixture of the second and third, even at 0·1 per cent. If, however, the spores were added to a crotonic acid solution and this suspension incubated on slides, the *ED*50 was less than 0·003 per cent. These results were interpreted to mean that crotonic acid was easily lost from the ester and from a deposit on glass, and that fungitoxicity of 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenyl crotonate depended on crotonic acid being present at the time of interaction with spores.

In greenhouse investigations begun here in 1952 on the chemical control of apple powdery mildew, *Podosphaera leucotricha* (Ell. and Everh.) Salm., using M.III rootstocks in small pots, no promise of control was offered at 0·05 per cent by salts or simple esters of crotonic acid, or by a considerable range of esters of unsaturated acids or alcohols, or by various other compounds containing unsaturated bonds in the molecule. On the other hand, technical grade 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenyl crotonate or the free phenol, isolated from the crude ester, gave, at 0·025 per cent, prophylactic control of the disease equal to that given by 1 per cent lime-sulphur, indicating that the phenolic portion of the 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenyl crotonate molecule is mainly responsible for fungitoxic action, in this case at least.

Recently, a more satisfactory method of infection has made possible more critical tests. Ten pots, each with one barley seedling or one apple rootstock bearing 2–3 shoots, were used for each treatment. Chemicals in aqueous formulation (1 per cent acetone and 0·025 per cent 'Triton *X*-100') were applied by dipping ; spores were applied later by settling in a tower. Lesions were counted after 7 days for barley and 9 days for apple. It is hoped to publish full details of the methods elsewhere.

The results of two trials on barley and one on apple are given in Table 1, the 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenyl crotonate and the free phenol being used in equimolar ratios, and ammonium crotonate in equimolar, quadrimolar or quinquemolar ratio. In all three tests, the free phenol gave as good protection as the ester, whereas ammonium crotonate gave little or no protection against barley mildew, and only 60 per cent reduction of apple mildew at the quinquemolar rate.

Table 1

Treatment	Concentration (per cent)	Barley		Apple
		Lesions per plant : First trial	Second trial	Lesions per leaf
Formulation control	—	40·9	92·5	6·87
DNOP	0·020	0·3	—	0·0
	0·016	—	0·2	—
DNOPC	0·025	0·2	—	0·0
	0·020	—	0·8	—
Ammonium crotonate	0·007	41·5	—	—
	0·028	—	115·2	—
	0·035	33·6	—	2·74

DNOP = the free phenol; DNOPC = 2 : 4-dinitro-6-(1-methyl *n*-heptyl)phenyl crotonate.

Further greenhouse trials have shown that control of apple and barley mildews comparable to that given by 1 per cent lime-sulphur can be obtained under these conditions with the free phenol at 0·0025 and 0·007 per cent, respectively. Moreover, a large degree of control was achieved at 0·01 per cent with 2 : 4-dinitro-6-*n*-octylphenol on apple, and with 2 : 4-dinitro-6-*cyclo*octylphenol on barley ; all the octyl isomers caused scorching of barley leaves, and the *cyclo*-octyl compound was toxic to apple also. The 6-*n*-hexyl and 6-*n*-heptyl homologues were also effective on apple, but very toxic to barley : the 6-*cyclo*hexyl homologue, dinex, was almost non-toxic to barley even at 0·05 per cent, but mildew control was poor. The 6-chloro homologue was very promising on barley, but very toxic to apple, at 0·02 per cent ; picric and picramic acids were safe at 0·015 per cent on barley but afforded little control of mildew.

It is well known that powdery mildews are largely unaffected by chemicals that are toxic to many other types of fungi. Thus the results obtained with 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenyl crotonate and its components on two powdery mildews, which were diametrically opposite to those reported by Rich and Horsfall for *S. sarcinaeforme*, might be peculiar to the Erysiphaceae. Results are therefore of interest from tests conducted with two well-known fruit pathogens, *Venturia inaequalis* (Cke) Wint., and *Botrytis cinerea* Pers. ex Fr., using a glass-slide spore-germination technique already described[2] that is basically similar to that used by Rich and Horsfall.

Table 2

Treatment	Concentration (per cent)	Inhibition of germination (per cent)	
		V. inaequalis	*B. cinerea*
DNOP, freed from ester	0·01	100	10·3
	0·001	33·5	1·5
	0·0001	4·6	0·0
DNOPC, freed from phenol	0·01	100	1·2
	0·001	19·2	0·0
	0·0001	14·6	0·0
DNOPC, crude	0·01	100	2·8
	0·001	31·1	0·0
	0·0001	0·0	0·0

DNOP = the free phenol; DNOPC = 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenyl crotonate.

Formulation was in 8 per cent acetone and 0·05 per cent sulphite lye, the spore suspension being placed on the dry deposit. The results obtained with both organisms, corrected to the formulation control by Abbott's formula, are given in Table 2, and leave little doubt that the activity of 2 : 4-dinitro-6-(1-methyl-*n*-heptyl)phenyl crotonate, crude or purified, is due almost entirely to the phenolic component, the ester probably being decomposed at some stage after deposition on glass, as it may well be on foliage.

We are indebted to our colleagues, Mr. R. P. Tew, for provision of 2 : 4-dinitro-6(1-methyl-*n*-heptyl)phenyl and several *n*-alkyl homologues, and Dr. M. H. Moore, for much help in developing methods and for recording the first series of trials, and to British Oxygen Research and Development, Ltd., for a gift of the *cyclo*-octyl homologue.

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Biosynthesis of Plant Glycosides from Uridine Diphosphate Glucose

The formation of glycosides and gentiobiosides after adding phenols or other substances to whole plant tissues has been observed by several workers[1-3]. Extracts of *Vicia faba* were reported by Miwa *et al.*[4] to form glucosides from vanillin, salicylaldehyde and hydroquinone. Tabone[5] prepared a partially purified enzyme from lentils which on addition of uridine diphosphate glucose and anthranilic acid formed a compound in which the carboxyl group of anthranilic acid was joined to a β-glucosyl residue.

The formation of phenol glycosides has been reported previously[6]: incubation of wheat-germ extracts with uridine diphosphate glucose and hydroquinone was found to lead to the appearance of a compound which appeared to be identical with arbutin (*p*-diphenol-β-glucoside) as judged by its mobility on paper before and after acid or enzymatic hydrolysis. Incubation of hydroquinone with other possible glucose donors, such as glucose-1-phosphate, sucrose, cellobiose or maltose gave negative results. Other phenols, such as saligenin (*o*-hydroxybenzyl alcohol), pyrocatechol (*o*-diphenol) and resorcinol, also reacted in the system to yield the corresponding β-glucosides, that is, salicin, pyrocatechol- and resorcinol-β-glucoside respectively.

In the course of studies on the formation of hydroquinone glucoside, it was observed that another substance besides arbutin was formed. As shown in Table 1, an unknown compound was found (R_F 0·08) in addition to hydroquinone (R_F 0·83) and arbutin (R_F 0·35) when the reaction mixture was chromatographed on paper.

In view of the lower mobility, it was considered likely that the compound with R_F 0·08 might have more than one glucose residue. Experiments carried out with arbutin instead of hydroquinone as substrate showed that the slowly moving compound (R_F 0·08) was formed more rapidly and in larger amounts. Up to 0·2 μmole was formed in 30 min. in the system mentioned in Table 1, with 2 μmoles of arbutin in place of 10 μmoles of hydroquinone.

For the identification of the new compound the reaction products were run on paper with butanol/pyridine/water (6 : 4 : 3) as solvent, thus obtaining a good separation from free glucose and from another unknown substance which remains near the origin with aqueous butanol. The new substance, after rechromatography and elution from the paper, gave an absorption curve in the ultra-violet very similar to that of arbutin. After acid hydrolysis in 1 *N* hydrochloric acid for 60 min. at 100° C. followed by paper chromatography, only glucose and hydroquinone were detected. Incubation with purified emulsin for 24 hr. gave glucose, arbutin and hydroquinone.

Estimation of phenol by the method of Folin and Ciocalteu[7] against an arbutin standard and of glucose by the phenol/sulphuric acid procedure[8] showed that the ratio glucose/phenol was about 2. The same results were obtained by estimating the glucose with an alkaline copper reagent[9] after complete hydrolysis with emulsin. By partial acid hydrolysis (10 min. in 1 *N* hydrochloric acid at 100°) followed by paper chromatography and development with alkaline silver[10] it was found that in addition to glucose a more slowly migrating sugar appeared. The latter was separated from parallel runs and compared with different disaccharides. Its behaviour proved to be identical with that of gentiobiose upon paper chromatography with several solvents (butanol/pyridine/water, 6 : 4 : 3; butanol/acetic acid/water, 4 : 1 : 5; and propanol/ethyl acetate/water, 7 : 1 : 2), and only glucose was formed on acid hydrolysis. Thus the results indicate that the compound is β-gentiobiosylhydroquinone. No mono- or di-glycosides were detectable in experiments in which the following substances were substituted for uridine diphosphate glucose: uridine diphosphate-acetyl glucosamine, guanosinediphosphatemannose, sucrose, glucose-1-

Table 1

Addition	Hours of incubation at 37° C.	R_F		
Uridine diphosphate glucose (1 μmole)	3	0·08	0·35	0·83
—	3	—	—	0·83
Arbutin (2 μmoles)	0	—	0·35	0·83
Arbutin (2 μmoles)	3	—	0·35	0·83

The system contained: 10 μmoles of hydroquinone, 50 μmoles of *tris* buffer *p*H 7·4 and 0·1 ml. of enzyme. Total volume 0·3 ml. The enzyme was prepared by extracting wheat germ with 3 volumes of 0·05 *M* phosphate buffer of *p*H 7, precipitating with ammonium sulphate between 0·2–0·5 saturation and dialysing. The deproteinized samples (ref. 9) were spotted on paper and run for 20 hr. with *n*-butanol saturated with water. Diazotized *p*-nitroaniline was used as developer (ref. 11).

phosphate, cellobiose, gentiobiose or maltose. Arbutin by itself was not hydrolysed or transglycosidated by the wheat-germ extracts, so that the mechanism of action is different from that described by Pridham[11], who reported the formation of β-gentiobiosyl-hydroquinone and glucose from arbutin with a plant β-glycosidase.

It thus appears that two transfer reactions from uridine diphosphate glucose are catalysed by the wheat-germ extracts: (1) the formation of the β-glucoside of hydroquinone (arbutin) and (2) the glycosylation of the glucose residue of the latter at the 6 position to yield gentiobiosyl-hydroquinone. It has not been established whether one or two enzymes are involved.

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Failure to induce Immunological Tolerance during Recovery from Irradiation

Neonatal animals and animals given large doses of whole-body X-irradiation are immunologically similar in two important respects: both are very poor producers of antibody, but both become satisfactory producers of antibody after several weeks, presuming that the X-irradiated animals survive. It is well established that during normal maturation animals go through a stage during which they may be rendered immunologically tolerant of certain antigens[1], and it seemed of considerable interest to determine whether, following severe X-ray damage, a similar stage occurred during which tolerance could be induced by appropriate antigenic stimulation. As X-ray damage is followed by rapid proliferation and differentiation of mesenchymal cells, be they the animal's own or bone-marrow cells grafted from a normal donor, it seemed possible that there might be a stage during which potential antibody-producing cells could be modified by contact with antigen and rendered immunologically tolerant.

Numerous workers, including Simonsen[2] and Nossal[3,4], have shown that the repeated injection of large amounts of foreign erythrocytes into embryos or neonates is followed by immunological tolerance. Accordingly, in the first series of experiments here reported, adult male *C3H* mice (bred by brother-sister matings for over forty generations) were exposed to 850 r. of whole-body irradiation, and 1–4 hr. later were given intravenous injections of isologous bone marrow. The bone marrow from six bones of one normal adult male donor was injected into each mouse. On the day following irradiation, and twice per week for four weeks during the recovery phase, the mice received intraperitoneal injections of 0·1 ml. of 20 per cent (packed cell volume) washed rat erythrocytes suspended in physiological saline. Normal adult *C3H* mice given a similar course of injections served as controls. One week after the last injection, the mice were bled, and the hæmagglutinin titre of the sera against rat cells determined. While the titre of one of the irradiated animals was much lower than those of the controls, it is clear from Table 1 that no immunological tolerance had resulted.

Table 1. Antibody Production in Lethally Irradiated Mice

Lethally irradiated bone marrow grafted mice (serum agglutinin titres)	Normal mice (serum agglutinin titres)
10,000	10,000
10,000	10,000
10,000	10,000
10,000	10,000
10,000	10,000
600	>10,000

Similarly, when adult mice were sublethally irradiated with 600 r., and injected with rat erythrocytes twice weekly for four weeks, all animals developed high titres of rat erythrocyte agglutinin. Next, the possibility that immature animals X-irradiated just after the end of the 'critical period'[2] for the induction of tolerance might be rendered tolerant by antigenic stimulation was explored. Day-old mice were given 500–700 r. of whole-body X-irradiation, and were afterwards injected twice weekly with 0·1 ml. of 20 per cent rat erythrocytes for four weeks. One week later, the agglutinin titre of their sera was determined. In three experiments out of four, all mice had high agglutinin titres. In the fourth experiment, similar in design to the other three, half the recipients had very low titres when compared with non-irradiated control mice given similar injections. However, even in this group the suppression of the immune response was temporary, and had almost disappeared when the mice were given two challenge injections of erythrocytes three months later.

Finally, attempts were made to save lethally irradiated adult mice with grafts of embryonic hæmopoietic tissue and to induce tolerance in this grafted tissue by antigenic stimulation. Attempts to use embryonic liver to save lethally irradiated animals were unsuccessful. Jacobson[5] has reported that about 30 per cent of lethally irradiated mice could be saved by injections of whole-embryo emulsion after irradiation. We were able to save about 20 per cent of our lethally irradiated animals by injection of 1·0 ml. of a mince prepared from 16–17 day-old mouse embryos. When these mice were injected with rat erythrocytes twice weekly for four weeks, the majority developed rat erythrocytes agglutinins. Most of the remainder developed high agglutinin titres when injected with further doses of rat erythrocytes three months later. Out of 15 animals examined, only one was still immunologically tolerant 20 weeks after irradiation, and it died shortly thereafter.

The failure to induce immunological tolerance in these circumstances is of considerable theoretical interest. It has been shown that mice lethally irradiated and saved with homologous bone marrow are thereby rendered immunologically tolerant of a skin graft from an animal of the donor strain[6]. During the very period when such a state of mutual tolerance is being developed, some cells, be it the proliferating grafted cells or the recovering host cells, evidently retain the capacity to produce circulating antibody to a heterologous antigen.

We wish to express our thanks to Sir Macfarlane Burnet for his interest in this work, and to the staff of the Peter MacCallum Cancer Clinic, especially Miss Betty Rose, for performing the irradiations. This work was aided by a grant from the National Health and Medical Research Council, Canberra.

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Acid-Soluble Nucleotides from the Blood of Metamorphosing Salmon

In a search for possible precursors to the guanine that appears in large amounts in the skin of the salmon (*Salmo salar*) at the transformation from parr into smolt, blood samples from fishes in different stages of metamorphosis were collected and subjected to ion-exchange chromatography. The blood samples were obtained by cutting the tails of a number of fishes (as nearly equal in size as possible) and collecting the blood in a vessel cooled by a mixture of acetone and 'dry ice'. The frozen samples were extracted with 0·6 *N* and 0·3 *N* perchloric acid, neutralized by potassium hydroxide, and put on a 'Dowex 1' × 2 column in the formate form. The various fractions were eluted by the gradient elution technique of Hurlbert and his co-workers[1], as modified by Schmitz[2]. Extinction values of each fraction were read at 260 and 280 mμ in a Beckman spectrophotometer model *DU*. The various components were identified by their characteristic 260/280 mμ ratios[3], by their positions in the chromatogram, and by their ultra-violet absorption curves. For further analysis appropriate fractions from the peaks in the chromatogram were pooled, desalted by passing through a 'Dowex 50' column, evacuated to dryness at 20° C. and finally dissolved in a small volume of distilled water. Using the millimolar extinction coefficients given by Hurlbert and co-workers[1] the various compounds were estimated quantitatively. Base–ribose-phosphate ratios were based upon measurements of ultra-violet extinction values, analysis of total and acid-labile phosphate by the method of Berenblum and Chain[4], and analysis of ribose with the orcinol – hydrochloric acid method as modified by Hurlbert *et al.*[1].

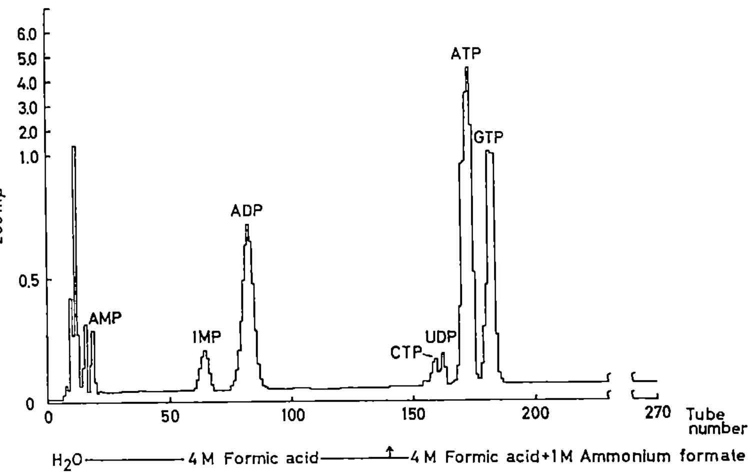

Fig. 1. Ion-exchange chromatogram of the acid-soluble nucleotides in the blood of metamorphosing salmon, taken during the pre-metamorphosis period (see text). 'Dowex 1' × 2 (200–400 mesh) column in the formate form, 0·9 cm. × 13 cm. Mixing volume, 250 ml.; flow-rate, 0·4 ml./min. Fraction volume, 5–4 ml. Key: AMP, adenosine monophosphate; IMP, inosine monophosphate; ADP, adenosine diphosphate; UDP, uridine diphosphate; ATP, adenosine triphosphate; CTP, cytidine triphosphate; GTP, guanosine triphosphate

It is apparent that with respect to nucleotide content of the blood, metamorphosis can be divided into three time-periods. The first, or pre-metamorphosis period, is dominated by a high guanosine triphosphate

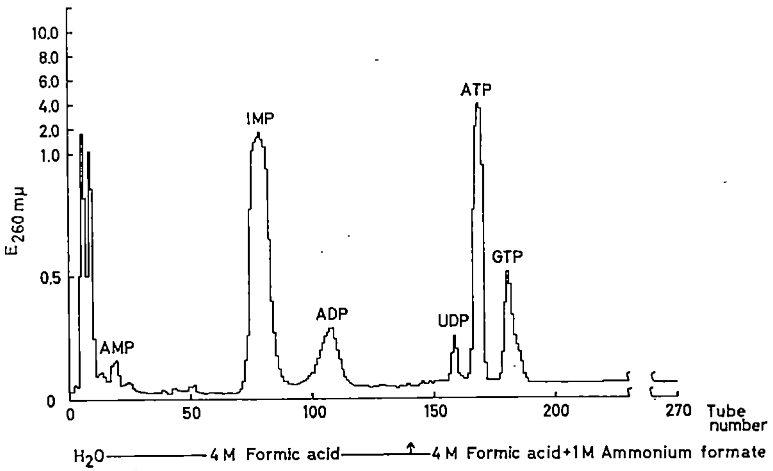

Fig. 2. Ion-exchange chromatogram of the acid-soluble nucleotides in the blood of metamorphosing salmon, taken during the metamorphosis period (see text). Conditions and key as for Fig. 1

and a low inosine monophosphate content (Fig. 1). During this period there is no pronounced deposition of guanine in the skin. The next period, the metamorphosis period, is characterized by a high inosine monophosphate content of the blood, a high rate of guanine deposition, and a reduced guanosine triphosphate content of the blood (Fig. 2). In the third or post-metamorphosis period the inosine monophosphate content of the blood has also been reduced to a low level so that, with respect to nucleotide content, the blood is quite comparable with that of a non-metamorphosing salmon.

A comparison with values for animal tissues given in the literature[5,6] indicates that guanosine triphosphate occurs in remarkably high concentrations in the blood of the salmon, especially during the pre-metamorphosis period, when it amounts to about 30 per cent of the adenosine triphosphate value. But also during non-metamorphosing periods the guanosine triphosphate content of the blood of salmon is high as compared with, for example, muscle tissues, which have been reported by Bergkvist and Deutsch[5] to contain guanosine triphosphate in amounts of about 1 per cent of that of adenosine triphosphate. The corresponding figure for the blood of salmon is about 10 per cent.

Full details of this investigation will be published elsewhere.

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Toxic Effects produced by Pyrimethamine in Chickens and their Antagonism by Folic Acid

PYRIMETHAMINE, a folic acid antagonist, has been shown to potentiate the activity of sulphadimidine and sulphaquinoxaline against cæcal coccidiosis in chickens (ref. 1 and Ball, S. J., private communication). During our investigation of this combination, the decreased growth-rate and anæmia observed in Rhode Island × Light Sussex chickens fed for 28 days on an all-mash diet containing 20 p.p.m. of pyrimethamine, appeared to be controlled by a dose of 10 mgm./kgm. folic acid. The mean weight gain over the experimental period is shown in Table 1.

Table 1. MEAN WEIGHT GAIN, MEAN CELL VOLUME AND MEAN CORPUSCULAR HÆMOGLOBIN CONCENTRATION IN CHICKENS AFTER 21 DAYS

Pyrimethamine in diet (p.p.m.)	Folic acid injections (i.p.) (dose × 2 weekly)	Mean weight gain (gm.) ± S.E.	Heart blood					Liver
			Red blood cell count (× 10^6/mm.^{3})	Hæmatocrit (per cent)	Hæmoglobin (per cent)	M.C.V. (μ^3)	M.C.H. ($\mu\mu$gm.)	Mean total iron content (mgm. per cent) ± S.E.
0	—	241·2 ± 19·14	2·41	30	9·1	126	35	37·7 ± 2·2
	100 mgm./kgm.	227 ± 20·1	2·38	29	8·7	121	36	33·8 ± 3·5
20	—	145·0 ± 16·95	1·18	18	6·3	154	52	82·2 ± 14·8
	100 mgm./kgm.	233·0 ± 13·06	2·46	30	9·5	119	38	40·0 ± 5·0

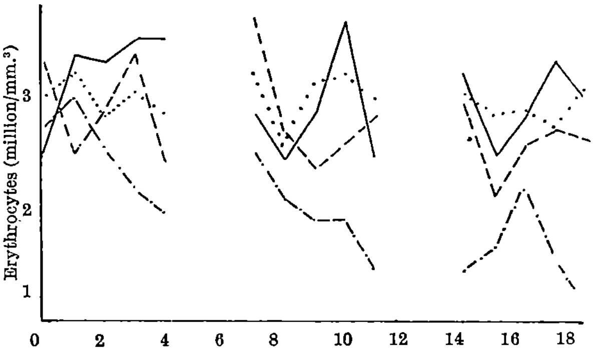

Fig. 1. ......, Control; —.—.—, pyrimethamine, 20 p.p.m.; ———, folic acid; ----, pyrimethamine 20 p.p.m. + folic acid

Daily erythrocyte counts were made in blood taken from the wing vein (Fig. 1). After 21 days the erythrocyte count, hæmatocrit and hæmoglobin concentration in the heart blood and the total liver iron content of each of the birds were measured (Table 1). Sections of liver, treated with potassium ferrocyanide, were examined for hæmosiderosis.

Pyrimethamine (20 p.p.m.) in the feed caused a significant depression of gain in weight ($P < 0.03$) and a macrocytic, hyperchromic type of anæmia. These effects were not present in the chicks receiving folic acid injections in addition to the pyrimethamine. The folic acid injections alone produced no effect on gain in weight or on the blood measurements.

There was a significant increase ($P < 0.05$) in the total iron content of the livers of the chicks (Table 1) receiving pyrimethamine only, and hæmosiderosis was noted in liver sections treated with potassium ferrocyanide, from the birds in this group. These latter observations suggest that a hæmolytic process, in addition to any effects produced on erythropoesis, is involved in the production of anæmia, a finding previously reported by Zach[2], who detected free hæmoglobin in the serum of rats receiving pyrimethamine.

From this work it appears that the toxic effects of pyrimethamine were caused by a state of folic acid deficiency, as they were controlled by the administration of folic acid.

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Effects of Reserpine on Secretion from the Adrenal Medulla

It is a well-established fact that reserpine causes a depletion of catechol amines[1] [2] in various organs. Whether this depletion is due to a decreased rate of synthesis or to an increased rate of release from the storage sites has not been clearly shown.

Changes in the content of catechols in the blood after administration of reserpine have been reported by Muscholl and Vogt[3], who found in rabbits, using biossay, an increase in venous plasma adrenaline but no measurable change in noradrenaline. In contrast, Burger[4] reports in man a distinct fall in plasma noradrenaline and a slight fall in plasma adrenaline, as measured by a fluorimetric method.

In the experiments reported here the purpose has been to determine whether reserpine causes secretion of medullary hormones into the adrenal venous blood.

To cats of both sexes, weighing 3–4 kgm. and anæsthetized with 'Nembutal' (Abbott), given intraperitoneally, 3 mgm./kgm. reserpine ('Serpasil', Ciba) was administered intravenously. Collections of adrenal vein blood were made at intervals using a special shunt technique (Schapiro and Stjärne, to be published). The adrenal vein plasma and the organ extracts were assayed biologically (cat's blood pressure and hen's rectal cæcum).

Reserpine was found to cause a transitory fall in blood pressure in every experiment except one, in which both vagi had been cut and the carotid sinus denervated bilaterally. In this case a gradual pressor effect was observed, lasting for 20 min. with a maximum value 40 mm. mercury above the resting level.

In every experiment reserpine caused a well-marked increase in the secretion-rate of both adrenaline and noradrenaline. The increase was already present in the first collection period 10–15 min. after reserpine was given; it reached its maximum value 1½–2 hr. later (Fig. 1). The effect on noradrenaline secretion was consistently greater than that on adrenaline, noradrenaline making up 75–90 per cent of the total catechols released. The amount of noradrenaline recovered in the adrenal vein blood in some experiments is so large that it suggests an increased rate of resynthesis, at least initially (Table 1).

The results of our experiments suggest that reserpine causes a relatively selective mobilization of noradrenaline. This is in accordance with the results reported by Eränkö and Hopsu[5]. These workers have shown by histochemical methods in rats that reserpine causes typical secretory changes almost exclusively in the parts of the adrenal medulla containing noradrenaline. The initially increased resynthesis-rate observed by us during the first 2–3 hr. after the administration of reserpine is of special interest in view of reports (refs. 6 and 7 and Bygdeman, S., and von Euler, U. S., personal communication) showing that direct electrical stimulation of the splanchnic nerve causes an acceleration of synthesis. However, the dose of reserpine used by us is known to cause an almost complete emptying of the adrenal medulla in 16–24 hr. Thus it seems clear that in the long run resynthesis cannot keep pace with secretion.

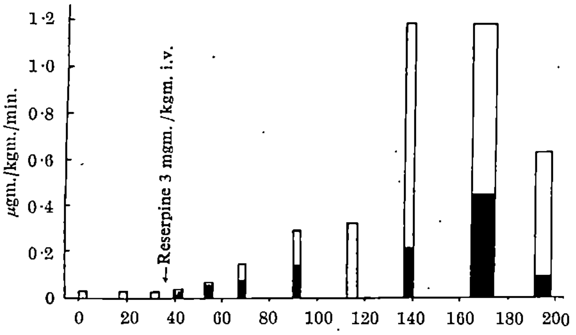

Fig. 1. Secretion of adrenaline and noradrenaline after the intravenous administration of 3 mgm./kgm. reserpine. White, noradrenaline; black, adrenaline

Table 1. Adrenaline and Noradrenaline in the Adrenal Medulla after Experiment 10, as compared to the Recovery in the Adrenal Vein Plasma after Reserpine

The calculation of the output is based on the assumption that during each shunt period the secretion can be represented by the average of the collection period immediately before and after it

Weight of left adrenal gland, 295 mgm.	Adrenaline (μgm.)	Noradrenaline (μgm.)
Content of left adrenal after the experiment (a)	62	15
Recovery in adrenal vein blood after reserpine (b)	91	282
Total amount recovered (a + b)	153	297

Other experiments of ours (in preparation) as well as by others[1,2] [8] indicate that the effect of reserpine on the adrenal medulla is to a large extent dependent on the innervation of the gland being intact.

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Behaviour of 19-nor-Progesterone and 19-nor-Ethinyltestosterone in the Liver of the Guinea Pig

The antiœstrogenic properties of 9-α-fluoro-11-β-hydroxyprogesterone are superior to those of 11-β-hydroxyprogesterone[1]. The halogenated compound resists inactivation in the liver[2]. This resistance has been corroborated in a new set of experiments (Table 1, *A*, *B* and *C*), from which it is evident that a given amount absorbed from an intrasplenic pellet (*B*) is less active than when absorbed from a subcutaneous one (*A*). There is no doubt, however, as to resistance of the halogenated compound in the liver (compare *B* and *C* with I*b*). Thus greater activity, namely, enhanced antifibromatogenic, antihysterotrophic and antiluteinizing properties of the halogenated, as compared with the non-halogenated

Table 1. EXPERIMENTS ON EIGHTY-EIGHT CASTRATED GUINEA PIGS RECEIVING DURING THREE MONTHS ŒSTRADIOL ABSORBED FROM SUBCUTANEOUSLY IMPLANTED PELLETS, AND VARIOUS ANTIŒSTROGENIC STEROIDS ABSORBED FROM SUBCUTANEOUS OR INTRASPLENIC PELLETS

Group	Antiœstrogenic steroid	Administered	No. of animals	Œstradiol (μgm./day)	Antiœstrogenic steroid tested (μgm./day)	Fibrous tumoral effect (average)	Coefficient Q_{2-3}*	Uterine weight	No. of pellets and concentration of compound (per cent)
A	9α-F-11βOH-P	Subcutaneous	7	44	1	1·4	0	1·6	1 ; 20
B	9α-F-11βOH-P	Intrasplenic	9	56	1	1·7	0·11	1·4	1 ; 20
C	9α-F-11βOH-P	Intrasplenic	7	44	8	1·9	0·14	1·9	1 ; 40
I*a*	Progesterone	Subcutaneous	10	48	9	1·5	0	3·3	½ ; 40
I*b*	Progesterone	Intrasplenic	8	53	12	7·8	2·5	4·2	½ ; 40
II*a*	19-nor-P	Subcutaneous	9	51	1·6	1·4	0	3·1	½ ; 20
II*b*	19-nor-P	Intrasplenic	8	48	1·1	5·7	1·7	5·9	½ ; 20
II*c*	19-nor-P	Intrasplenic	6	45	9	3·0	0·7	5·6	½ ; 40
III*a*	19-nor-ET	Subcutaneous	14†	50	80	2·0	0·3	2·6	½–1 ; 100
III*b*	19-nor-ET	Intrasplenic	10	46	65	2·0	0·2	3·8	½ ; 100

* Taken for comparison from ref. 5*a*. † See ref. 1*b*.

compound, could be explained, in part at least, by a different behaviour of the two compounds in the liver.

The question now arises whether the same is true for 19-nor compounds. The antiœstrogenic activity of 19-nor-progesterone (19-nor-P) is (like its progestational potency[3]) much greater than that of progesterone[4]. It is the same with 19-nor-ethinyltestosterone (19-nor-ET)[5], and 19-nor derivatives of testosterone compared with the natural androstenes[6].

We have now studied the antifibromatogenic action of progesterone and 19-nor-progesterone absorbed from pellets implanted in the spleen. The results show that both substances are undoubtedly inactivated in the liver (Table 1; for details see Fig. 1). With intrasplenic pellets of either progesterone or 19-nor-progesterone (I*b* and II*b*) the fibrous tumoral effect is as great as in animals receiving œstrogen only; similar quantities absorbed from subcutaneous pellets (I*a* and II*a*) produce a very notable antifibromatogenic effect. The same holds for the comparative antihysterotrophic effects with subcutaneous and intrasplenic pellets.

One might argue that in II*b*, with intrasplenic pellets of 19-nor-progesterone, the average quantity absorbed per day was somewhat smaller than in II*a* with subcutaneous pellets. But this argument is invalidated by the fact that, even with 9 μgm./day of 19-nor-progesterone absorbed from intrasplenic pellets (II*c*), no definite antifibromatogenic effect is obtained which would be comparable to that obtained with a quantity five or six times smaller when absorbed from subcutaneous pellets (II*a*). Indeed, the fibrous tumoral effect in II*c* was not so great as in I*b* and II*b*. But this insignificant antitumorigenic effect was evidently due to very small quantities of the highly active 19-nor-progesterone which escape intrahepatic inactivation; the same happens even with the less-active progesterone when absorbed from intrasplenic pellets[7].

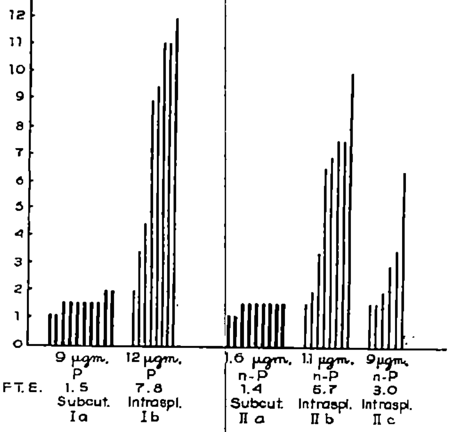

Fig. 1. Fibrous tumoral effect (FTE) in arbitrary units in guinea pigs with subcutaneously implanted pellets of œstradiol. Thick lines, animals with an additional subcutaneous pellet of progesterone or 19-nor-progesterone. Thin lines, animals with an additional intrasplenic pellet of progesterone or 19-nor-progesterone. When absorbed from the spleen both progesterone and 19-nor-progesterone lose their antifibromatogenic activity

Experiments with 19-nor-ethinyltestosterone are also of interest. It is known that progestational action can be obtained with ethinyltestosterone when given by mouth; this presupposes good resistance in the liver. The antifibromatogenic potency of ethinyltestosterone is inferior to that of progesterone and reaches only that of testosterone[8]; but 19-nor-ethinyltestosterone is several times as potent as ethinyltestosterone[1c, 5b]. How will 19-nor-ethinyltestosterone behave when absorbed from an intrasplenic pellet? A comparison between III*a* and III*b* (Table 1) shows that there is no difference in the results obtained with subcutaneous and intrasplenic pellets of 19-nor-ethinyltestosterone. Thus the latter resists inactivation in the liver. In other words, the 19-nor configuration is of no consequence with regard to resistance in the liver (19-nor-ethinyltestosterone), and neither is it of any consequence as to non-resistance (19-nor-progesterone).

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Conditions which eliminate Inflammation to Homografts in Rabbits

THE stimulus for production of a sterile cellular infiltrate, principally lymphocytic, in and about a homograft remains obscure. Methods whereby this inflammatory reaction may be eliminated are worthy of consideration with the view of successful homografting between members of genetically impure strains.

Previous studies using musculofascial transplants of erector spinæ of rabbits permitted accurate distinctions to be made by ordinary histological methods between autografts and homografts[1]. Microscopic examination two weeks after implantation showed that both types of grafts underwent similar sequences of degeneration, resorption and organization, but in the homograft inflammation was superimposed upon the repairative matrix of the musculofascial zone. Angiitis involving the newly formed channels was a frequent feature of the inflammatory reaction.

Further experiments have shown that the classical inflammatory aspects of host–homograft interactions may be eliminated by several conditions. One condition was by reduction of 'viability' of tissues of the musculofascial graft by exposure to extremes of heat, cold or X-irradiation prior to implantation[2,3]. Both types of grafts so treated elicited a sluggish fibro-collagenous response by the host. Grafts studied following less extreme exposure to temperature and X-irradiation showed that the degree of admixture of proliferating cells of the graft with those of the host seemed to determine the magnitude of the inflammatory reaction in homografts.

A second condition for the elimination of inflammation in homografts required grafting between parabionts in the post-parabiotic period. Rabbits surgically united by the ears developed a cross-circulation lasting between 7 and 13 days after anastomosis[4]. The cessation of the cross-circulation seemed to be related to the development of inflammation at the surgical plane of anastomosis between the animals. Joining rabbit parabionts a second time failed to reproduce sequences of healing noted at primary junctions. This was in accord with the "second set rejection phenomenon"[5]. Microscopic study of cross-homografts between parabiotic partners following one and two periods of parabiosis showed two types of tissue reaction equally distributed between the two groups of parabionts[6]. The first type consisted of a fibro-collagenous encapsulation of the graft by the host in the absence of vascular penetration. Inflammation did not develop. The second type of post-parabiotic modification was similar to the first, with the exception that a peculiar angiomatous vascular plexus of capillaries arising from the host grew beneath the fascia of the homograft. Inflammation was again absent.

The third condition required cross-transfusion. Since a transient cross-circulation was a conspicuous feature of the primary healing between parabionts, cross-transfusions of whole blood, controlled in quantity, were done between pairs of rabbits[7]. This eliminated all factors involved in parabiosis except exchange of blood. The microscopic study of cross-homografts following cross-transfusions showed a vascularizing stromal penetration identical to the second type of host–homograft interaction following parabiosis. Inflammation was absent.

A fourth condition required for elimination of inflammation in homografts was the pregnant state. Gravid rabbits (13–15 days of gestation) were cross-grafted with males and non-pregnant females of the same species[8]. Autografts were also implanted. Each pregnant host reacted in the same way to autografts and homografts. Both types of grafts showed the usual sequences of degeneration, absorption and organization in the absence of inflammation characteristic of host–autograft reactions. It appeared that pregnancy lessened the capacity of the animal to react against grafts of normal homologous tissues.

These observations have indicated that investigation of the means by which the inflammatory aspects of host–homograft interactions are eliminated may offer clues to the solution of the problem of successful homografting.

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Sarcoma in Albino Rats treated during the Embryonic Stage with Rous Virus

THE cystic-hæmorrhagic disease[1,2] of albino rats caused by the Rous sarcoma virus indicates that the rats are susceptible to this virus. Starting from the well-known work of Duran-Reynals[3,4] I have attempted to reduce the susceptibility of the rats to the Rous virus by treating embryos with specific antibodies. The technique of inoculation has been described elsewhere[5].

0·1–0·15 ml. 50 per cent homogenate of the Rous sarcoma was injected subcutaneously into each embryo of four laparotomized pregnant white rats. Concurrently 0·2–0·25 ml. antiserum of rabbits repeatedly immunized with the homogenate of the Rous sarcoma was injected intraperitoneally into the same embryos. Of the four pregnant rats, two aborted, one gave birth to and suffocated its litter, and only one bore successfully five rats, of which two were suffocated.

In two of the three surviving rats small, very slowly growing cysts developed one month after the inoculation, but these regressed in course of time; 6 and 7 months thereafter sarcomata developed in these two rats. In one of them sarcoma appeared on the dorsal side of the neck, precisely at the site of primary infection with the Rous virus. The tumour attained the size of an apricot; histologically it was a sarcoma with a significant polymorphism resembling the Rous sarcoma. In the tissue spindle-like cells predominated, along with rounded cells and much mucopolysaccharide. In the second rat a 2-cm. sarcoma with spindle-like cells developed on the cheek.

The sarcoma was minced with scissors and subcultured in rats of various ages. It grew well in new-born rats, and within 20–25 days reached a large size, causing death in some animals. In young rats (50–60 gm.) growth of the tumour proceeded more slowly; it attained a large size in some of them. The weight of the tumour in such cases reached the weight of the rat itself, although in some individuals growth was poor, being followed by regression. In adult rats weighing 120–150 gm. the tumour reached the size of a bean and was then resorbed. In new-born and young rats the tumour grew on the second and third passages as well. Here the tumours were characterized histologically by appreciable homogeneity, being composed exclusively of spindle-shaped cells containing less mucopolysaccharide and being more solid than the initial tumour. The inoculation of minced rat sarcomata to chickens was unsuccessful. It is possible that the Rous virus is present in the rat tumours in the masked form.

It might seem that the inhibition of the pathogenic effect of the Rous virus by antiserum led to the development of sarcomata instead of the typical cystic-hæmorrhagic disease in rats infected during the embryonic period. Yet in one of the rats inoculated with the Rous virus during the prenatal period, without additional treatment with antiserum, a slowly growing cyst developed, which, seven months afterwards, was replaced by a huge sarcoma.

These experiments were carried out on rats of a stock free from spontaneous malignant tumours.

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Hydrogen Peroxide Ingestion and the Growth of Rats

SEVERAL recent communications have dealt with the capacity of ingested hydrogen peroxide to affect the regression of implanted tumours in rats. Holman[1] has claimed that a 0·45 per cent solution of hydrogen peroxide given to rats in lieu of tap-water caused regression of certain tumours; the opposite conclusion has been stated by Green and Westrop[2] and by Ghadially and Wiseman[3]. Accordingly, it seemed important to determine the effect of hydrogen peroxide on normal rats.

In one experiment, two groups of weanling male rats of the Osborne-Mendel strain developed at this Station were given a commercial dog food meal, and either tap-water or 0·45 per cent hydrogen peroxide *ad libitum* for a three-week period. During the test period, the animals on tap-water consumed an average of 544 ml. each, whereas those on peroxide averaged only 282 ml. each. The decreased amount of liquid intake was reflected in the total body-weight; 156 gm. for those on tap-water against 108 gm. for those on peroxide. No differences in the fresh weight of the testes, kidneys or spleen of the two groups were found.

In order to equalize any effects of limited intake of liquid, another group of male weanling rats was offered 0·45 per cent hydrogen peroxide in lieu of tap-water for a three-week period. Daily consumption was recorded, and a comparable group of male weanlings was given an amount of tap-water equal to the liquid consumed by the animals on peroxide. This regimen was also continued for a three-week period. It was observed that the group of rats on tap-water were continually seeking water, whereas those on peroxide did not act in a similar manner. The average body-weight was 116 gm. for those on peroxide and 104 gm. for those on tap-water. An attempt was made to see if ingestion of peroxide affected the fresh weight of some of the internal organs. Calculated in terms of percentage of body-weight, no important differences were found in the testes, kidneys, spleen or heart. The dry weights of these same tissues, calculated as percentage of body-weight, also failed to show differences.

Three weanling females were placed on a 0·45 per cent hydrogen peroxide regimen and maintained on it for five months. They were then given tap-water instead and were mated with normal males. Normal litters were produced. Six male litter mates were divided into two equal groups: one received peroxide while the other received tap-water. The animals were maintained on their respective regimens for nine months. The only noticeable effect was a difference in body-weight; an average of 521 gm. for those on tap-water against 411 gm. for those on peroxide. Three older males with an average weight of 600 gm. were given 0·45 per cent hydrogen peroxide for six weeks. At that time their average weight had fallen to 511 gm. They were then given tap-water and within two weeks had regained the lost weight.

Weanling rats offered the hydrogen peroxide *ad libitum* failed to gain weight normally. Although it had previously been shown that larger rats fed peroxide failed to gain weight normally[3], this phenomenon has not previously been noted for weanlings. Ghadially and Wiseman[3] attributed the loss of weight to diminished food intake; but, as noted above, this result may also be caused by a diminished liquid intake. Furthermore, long-term feeding of peroxide did not appear to affect reproduction in female rats.

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Role of Hypersensitivity in Experimental Staphylococcal Infection

It was shown previously[1] that a mild staphylococcal infection in rabbits can produce a state of both skin and systemic delayed hypersensitivity with some signs of immunity. Antitoxin formation, increased bactericidal activity of leucocytes and increased clearing of injected staphylococci from the blood and organs was found. Yet after a challenge with intravenous staphylococcal infection these rabbits died more rapidly and in larger numbers than normal controls. It has been also reported[2] that after production of hypersensitivity of the delayed type in guinea pigs using immunization with staphylococcal vaccine in Freund-type adjuvant, more numerous and larger abscesses are formed during the following infection; this conclusion has been given without detailed experimental results. In the experiments presented here an attempt was made to transfer to normal recipients this state of lowered resistance to staphylococcal re-infection passively, using cells of hypersensitive donors.

The desired state of hypersensitivity was produced in chinchilla rabbits by repeated intradermal and intravenous infections with small doses of staphylococci. Animals were selected after some weeks of treatment according to the intensity of skin reactions to diluted staphylococcal toxoid and vaccine given intradermally; in addition, α-antitoxin and agglutinin blood titres were determined. Spleen cells or peritoneal exudate cells (saline, 4 hr.) were transferred intraperitoneally to normal recipient rabbits; 200–300 million living cells were used. The exudate consisted of 10–30 per cent lymphocytes, 70–90 per cent polymorphonuclears and 5–10 per cent macrophages.

Normal rabbits with negative skin tests and without ascertainable antibodies were used as recipients and control donors. On the day following transfer the recipients were tested with staphylococcal toxoid and vaccine and reactions were recorded after ½, 2, 6, 24 and 48 hr. Following the last reading the animals were infected intravenously with 20 million micro-organisms of a virulent staphylococcal strain. Bacteriæmia was studied during infection and in some experiments the number of micro-organisms in different organs was also determined. Values of bacteriæmia for the last 24 hr. before death are not given.

As expected[3], transfer of cells resulted in skin hypersensitivity of the delayed type in the recipients. The results of staphylococcal infection in the experimental and control groups of rabbits are summarized in Table 1. It is evident that increased susceptibility to staphylococcal infection can be transferred with living cells from hypersensitive animals, while killed cells (65° C. for 30 min.) and cells from normal rabbits are without effect.

Table 1. Results of Staphylococcal Infection in Different Experimental Groups

	No. of rabbits	Deaths	Survivals	Deaths (per cent)
Hypersensitive rabbits	21	17	4	81
Recipients of hypersensitive cells	38	27	11	71
Recipients of killed hypersensitive cells	19	5	14	26
Recipients of normal cells	12	3	9	25
Normal rabbits	24	5	19	21

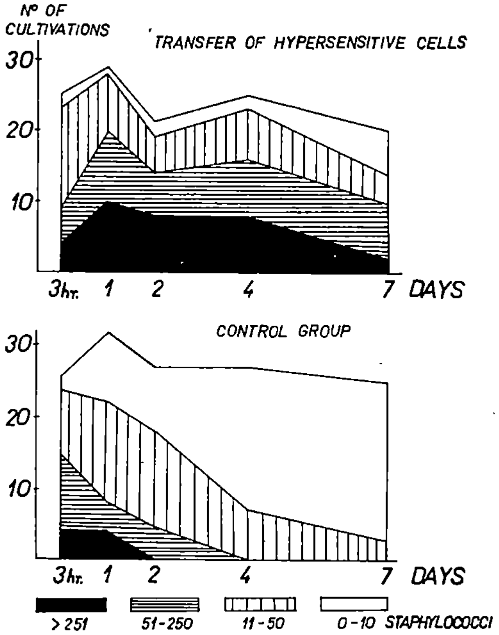

Fig. 1. Numbers of staphylococci cultivated from 1 cm.^{3} of blood during intravenous infection in rabbits passively sensitized with cells and in control rabbits

The bacteriæmia in rabbits previously sensitized with cells of hypersensitive rabbits remains high in the course of infection, while the bacteriæmia in control groups (normal rabbits, rabbits receiving normal cells or killed hypersensitive cells) declines progressively (Fig. 1). More micro-organisms are also found in organs. Cultivation from animals killed 48 hr. after infection gave the following average values per 100 mgm. organ-weight: in rabbits passively sensitized with cells—liver, 147; spleen, 156; lungs, 139; in control rabbits—liver, 3; spleen, 3·5; lungs, 4·5 micro-organisms.

The above results show that the state of increased susceptibility to staphylococcal infection can be transferred to normal recipient rabbits by means of living cells together with the delayed hypersensitivity to staphylococcal antigens. There is no direct evidence that there is a causal relationship between these two phenomena. There is no negative evidence, however, and no other reasonable interpretation can be given. It seems probable that the influence of hypersensitivity on the course of staphylococcal infection is due to changes (injury of cells, inflammation, etc.) that occur in tissues of sensitized animals after contact with the antigens of the infecting micro-organism; these changes may provide better conditions for the development of staphylococcal infection.

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Plasma Cells and Tumour Growth

Growth and regression of a tumour in experimental animals are known to be accompanied by various changes in the organs of the host, especially in the lymph nodes and spleen. Although there is a close association between immunity to a transplantable tumour and presence of local cellular infiltrations of, say, lymphocytes and plasma cells, there has been a wide diversity of opinion as to the specific cell or cells involved.

It is generally agreed that homografts of normal and tumour tissues are destroyed by a 'specific immune' reaction, but this still lacks the confirmation of direct demonstration of the presence of any antibody. Recent work has shown that plasma cells are involved in the production of antibody against bacterial, viral and other foreign protein antigens[1]. Several workers have also observed plasma-cell development in the host, following tumour[2] and normal tissue homografts[3].

I have approached the problem from a different angle, namely, by demonstrating plasma-cellular reaction in the tissues of the host, which may be considered as a pointer to the immunological changes taking place. A detailed histological and cytological study was made in rats to observe the local and remote reactions in the host, following transplanted and induced tumours, during the stage of progressive growth and regression, with special reference to the plasma-cell equipment.

Tuck male albino rats were employed throughout. Transplantable *Rd*/3 rat sarcoma (originally induced by 1 : 2 : 5 : 6-dibenzanthracene) and Walker carcinoma were used. Tumours were implanted subcutaneously into the right flank. Induced tumours were produced by subcutaneous injection of 1 : 2 : 5 : 6-dibenzanthracene in arachis oil. Tumour (*Rd*/3 and Walker) inhibition and regression were induced by intraperitoneal injection of 1 : 2 : 5 : 6-dibenzanthracene (2 mgm./100 gm. of body-weight) suspended in 0·2 per cent 'Teepol'. Animals were killed at different stages of tumour growth, inhibition and regression. Histological sections and smear preparations were made from these tumours and different organs, and stained with hæmatoxylin and eosin and Unna-Pappenheim (methyl-green and pyronin). The amount of plasma cells was estimated from these preparations.

In the normal rats, the lymph nodes, specially the axillary and para-aortic (lumbar) and the spleen contain very few plasma cells, mostly mature in type, in the medulla and red-pulp respectively. The main cellular constituents are the lymphocytes.

During the progressive growth of the transplanted tumour (*Rd*/3 and Walker), the draining lymph nodes, namely, the right axillary and para-aortic and the spleen are increased in weight. Some of these enlarged lymph nodes show hæmo-lymph node formation. Histologically, in the lymph node, the medulla is increased in size, replacing the cortical lymphoid tissue and the sinuses are dilated. The broad medullary cords are crowded with proliferated reticulum cells and plasma cells (immature and mature), accompanied by diminution of lymphocytes. Russell-body cells are also found. Mitoses are frequent. No increase of plasma cells is seen in the cortex. In the hæmo-lymph nodes, large numbers of erythrocytes are found in the sinuses and many free macrophages show erythro-phagocytosis. In the spleen, the red pulp is highly cellular and shows proliferation of reticulum cells and increased number of immature and mature plasma cells, specially around the trabeculæ. The Malpighian follicles are not much affected and no increase of plasma cells are found. Transitions from reticulum cells to mature plasma cells are seen.

There is a significantly constant relation between the amount of plasma-cell response, weight of these organs and of the tumour. No definite relation between plasma-cell increase, hæmo-lymph node and metastasis formation is found. Moreover, the lymph nodes having secondary metastases show a marked diminution of plasma-cell reaction. A similar but less marked change is observed with tumours induced by dibenzanthracene.

The local reaction of the host around the tumour during its progressive growth is slight and the cellular infiltration is scanty, consisting of lymphocytes, macrophages, plasma cells and a few polymorphonuclear neutrophils, embedded in a connective tissue. Experimentally induced tumour inhibition and regression are regularly associated with an increased local reaction of the host around the tumour, consisting of accumulation of large numbers of plasma cells, without any appreciable alteration of the lymphocytic infiltration. This local plasma-cell accumulation is more numerous about the nodules of viable tumour cells, and in a few instances appeared to have invaded them, resulting in their degeneration and disappearance. When the tumour cells are no longer present, the local reaction subsides and the plasma-cell accumulation diminishes.

Following induced regression of the transplanted tumour, the animal becomes resistant to a subsequent challenge with the same tumour at a different site. Presence of living tumour cells is essential for this plasma-cellular response. Heat-killed tumour graft, which is no longer capable of stimulating this response, fails to render the host resistant to a subsequent inoculation with living tumour cells. Such a phenomenon is strongly suggestive of the presence of a circulating antibody.

These findings suggest that the increased response of plasma cells is the morphological manifestation of a systemic immune reaction to circulating antigen(s), which leave the graft, and reach the regional lymph nodes and spleen, where they excite this reaction, like any other antigens, and that plasma cells are involved in the production of antibodies. Other elements do not appear to have the same significance. Attempts to identify the antigenic substance in the tumour have so far been inconclusive.

Recent study of the nucleic acid content also supports the participation of draining lymph nodes in the formation of antibody against the transplanted tumour, and ribonucleic acid in these organs has been found to be increased, suggesting synthesis of protein[4]. Such enlarged lymph nodes have also been shown to take part in the immunological response conferring passive tumour transplantation immunity in secondary hosts[1,5]. Using the Schultz–Dale technique, it has been demonstrated that the presence of antibody in the host is the basic mechanism involved in this passive tumour transplantation immunity[1]. Further, the growth of the tumour cells is inhibited by treating them *in vitro* with excess of splenic and lymph-nodal cells from tumour-bearing animals. The only histologically demonstrable change in these organs taking part in the immunological phenomenon is the increased accumulation of plasma cells.

Cortisone, which abrogates the resistance to homo- and heterologous tumour grafts, inhibits this plasma-cell response in these organs. But once the immune reaction is established, cortisone fails to interfere with it, in spite of damage to the lymphocytes. This shows that cortisone strongly depresses antibody formation to antigens of the transplanted tumour tissue, by inhibiting plasma-cell development. These findings further show a constant relation between the plasma-cellular reaction and tumour resistance, which cannot be explained in terms of lymphocytes.

The conclusion which can be drawn from this study is that during reaction to bacterial and other foreign protein antigens, tumour and normal tissue-grafts, the plasma-cellular response may be considered as a pointer to the immunological change taking place. Judged by the plasma-cellular reaction, transplantation immunity to tumour and normal tissues conforms with the immune state generated by bacterial and other foreign protein antigens.

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Resistance to Flow in Vascular Beds

Dr. S. D. Carlill[1] has attacked the standard concept of resistance to flow (R) as the ratio of the driving force (the pressure drop P across the bed) to the flow F, and advocates that the 'dynamic resistance', that is, the differential dP/dF be substituted. His argument seems to assume what he is trying to prove.

Derived measures, or indices, depend for their usefulness on concepts that may underlie them. The standard measure of electrical resistance, in ohms, is used because we know that the applied potential difference plays a primary part in determining the current. Use of the ratio of voltage drop to current then allows us to remove the influence of this primary factor at the outset, and to concentrate on the other factors that determine the flow in a particular conductor. These factors are the specific conductivity of the material of the conductor, and its 'geometrical factor', that is, length over cross-sectional area.

The usefulness of the ohm is in no way dependent upon linearity between applied voltage and current. In modern electronics, perhaps the majority of the circuit components are non-linear (do not obey Ohm's law), yet we still use the ohmic resistance. We recognize, however, that the resistance of these components is not independent of the applied voltage, or of the current flowing. After all, Ohm's law itsel has to make the condition that the resistance of a given conductor is constant, independent of the applied voltage, only if the temperature is kep constant (and actually the temperature must depen on the current flowing). By using the ratio of potential drop to current, that is, the ohmic resistance we can study how the ratio depends upon othe factors, including the voltage or current in non-linear cases.

With 'Newtonian' fluids flowing in cylindrical non distensible tubes, Poiseuille's law applies. This is best written :

$$F = P \times \left(\frac{\pi}{8}\right) \times \left(\frac{1}{\eta}\right) \times \left(\frac{r^4}{l}\right) \qquad (1$$

$$= P \times (N) \times (V) \times (G) \qquad (2)$$

where F is the flow, P the drop in pressure, (N) is the 'numerical factor', occurring in the integration of Hagen's theoretical treatment, (V) is the 'viscosity factor', and (G) is the 'geometrical factor' (r = radius, l = length of tube). On the standard definition, the resistance R is given by :

$$R = \frac{P}{F} = \frac{1}{(N) \times (V) \times (G)} \qquad (3)$$

In the case cited, R is independent of P and of F.

When the flow-pressure curves are non-linear, as they are with blood flowing in vascular beds[2], we can legitimately consider that equation (3) still applies under any given condition of pressure and flow, but either the viscosity factor (V) or the geometric factor (G) is not constant but depends upon the pressure and the flow. If the vessels are distensible, their 'geometrical factor' (G) alters with the 'transmural pressure' of each of the vessels. If the fluid is non-Newtonian, having an 'anomalous viscosity', the viscosity factor (V) will depend on the rate of flow. Resistance of a vascular bed, therefore, depends on the pressure (not primarily upon the driving pressure, but on the 'transmural pressure'—for example, a rise of venous pressure greatly affects the resistance even if the driving pressure is kept constant[3]). The curves of resistance versus pressure are much as shown in Dr. Carlill's Fig. 1, and this has been pointed out many times by us and by others[1].

The point is that, in spite of this consideration, the resistance to flow, as the ratio of P/F, still tells us what the product of geometrical factor (G) and the viscosity factor (V) is for that set of conditions of pressure and flow. If, as fortunately it turns out to be, the viscosity factor has not changed appreciably[4], the change in the geometrical factor can be deduced from the change of resistance. If the resistance has increased, the vessels have become 'narrower'; if it has decreased the vessels have 'widened'. This is a big step in clarification, even though the question remains as to why the calibre of the vessels has changed. Was it because of a change in transmural pressure, or was it due to an 'active vasoconstriction' or 'vasodilation' (that is, due to contraction of the smooth muscle of the wall)? Often this question can be decided, in other cases not. For example, if the resistance has increased but the pressures has not changed or has risen, this must have been active vasoconstriction, for the distensible vessels would passively decrease in size only if pressures fell. Thus the use of 'resistance to flow' greatly clarifies such problems.

Let us now consider Dr. Carlill's substitute for the conventional 'resistance', the 'dynamic resistance' dP/dF, derived from the slope of the flow-pressure curve. The 'instantaneous resistance' or its reciprocal, the 'transconductance', is, of course, familiar in electronics, where the slope of the characteristic for a given set of operating voltages, etc., is used in calculating amplification factors and the like. There will be a set of problems in hæmodynamics where the analogous 'dynamic resistance' is useful. These are those where the rate of change of flow in a vascular bed with change of blood pressure is relevant, for example, problems of control of circulation and its homœostasis. In our laboratory we have recognized this, as in the work of Girling[5], which points out how the level of blood pressure can greatly modify the effectiveness of the sympathetic activity.

Can the 'dynamic resistance' give us information, in any simple manner, as to what is happening to the calibre of the vessels ? Differentiating equation (2) to derive the 'dynamic resistance' R' :

$$\frac{1}{R'} = \frac{dF}{dP} = N\left[V.G + P.V.\frac{dG}{dP} + P.G.\frac{dV}{dP}\right] \qquad (4)$$

If there were only the first term in the brackets we could associate changes in resistance with changes in the geometrical factor of the viscosity factor or both, but in non-linear cases the second and third terms may completely dominate the whole expression. A striking example where the substitution of the slope for the conventional resistance would lead to a paradox is at pressures close to the 'critical closing pressure' in vascular beds under considerable vasomotor tone. In this case the flow–pressure curve is markedly concave towards the pressure axis, and the slope becomes very steep as the point of zero flow is approached. One would be forced to say that the 'resistance' (that is, the 'slope' or 'dynamic' resistance) had become very low, for a very small change in pressure produces a large change in flow. Yet at the point where this 'dynamic resistance' is decreasing to a low value, the vessels are actually closing down. Clearly, no useful concept of the connexion between this 'dynamic resistance' and the size of the lumen of the vessels is possible. By all means let us use the 'slope' of the flow-pressure curves in proper context, but we must not substitute this 'dynamic resistance' for the standard 'Ohmologous' resistance of standard hæmodynamics. If we do, we are likely to make confusion worse confounded.

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Production of Mutants of Tobacco Mosaic Virus by Chemical Alteration of its Ribonucleic Acid *in vitro*

WHILE many agents are known to act as mutagens on the living cell, there have been no convincing reports that the genetic character of isolated particles, such as viruses or transforming principles, have been changed *in vitro*. Recent results with tobacco mosaic virus help to overcome this difficulty. The infective unit of the virus is its ribonucleic acid component, which can be isolated in active form[1]. It is made up of 6,000 nucleotides that probably form a single chain[2].

Recently, Schuster and Schramm[3] have used nitrous acid to convert adenine, guanine and cytosine into hypoxanthine, xanthine and uracil, respectively, while the ribonucleic acid strand remains intact. It was shown that the alteration of any one of about 3,000 nucleotides is lethal. Possibly, changes of other bases are mutagenic.

Table 1. MUTAGENIC EFFECT OF NITROUS ACID ON RIBONUCLEIC ACID. 2 vol. of 0·19 per cent ribonucleic acid extracted from tobacco mosaic virus *vulgare* by phenol (ref. 1) were mixed with 1 vol. 4 M sodium nitrite and 1 vol. 1 M acetate pH 4·8 at 22° C. After time t, the ribonucleic acid is diluted to 19 μgm./ml. with $M/15$ phosphate, and assayed. Control dilutions of untreated ribonucleic acid contain an equivalent amount of nitrite. Time τ (equation 1) is 18·5 min. Total infections are given as numbers of lesions (per leaf) on Xanthi, and as the sum of chlorotic and necrotic lesions on Java ; mutant infections as numbers of necrotic lesions per leaf on Java

t (min.)	t/τ	Total infections		Mutant infections	Mutant infections (per cent)
		Xanthi	Java	Java	Java
1	0·05	72·8	183	1·4	0·8
4	0·22	72·4	130	2·5	1·9
8	0·43	89·8	188	4·5	2·4
16	0·86	59·3	97	5·4	5·6
32	1·73	36·1	63	6·6	10·5
64	3·46	10·4	21	2·1	9·8
96	5·2	2·7	3·5	0·5	15·5
Untreated controls, μgm./ml. ribonucleic acid					
19		155	138	0·3	0·2
1·9		31·2	42	0·1	0·3
0·19		3·1	10	0	—
× 0·019		0·3	0·8	0	—

On the basis of this work we studied a simple symptom of mutation, the production of necrotic lesions on a tobacco variety (Java) on which the untreated strain produces chlorotic lesions only. Virus or isolated ribonucleic acid was treated with nitrous acid. After times t, samples were diluted to a constant concentration for assay on Xanthi and Java tobacco plants. The conditions and results are given in Table 1. The total concentration n of infective particles was measured by the number of lesions on Xanthi, and of chlorotic and necrotic lesions on Java tobacco, as compared with standard dilution curves. n decreases exponentially with t :

$$n = n_0 \exp(-t/\tau) \qquad (1)$$

where τ is the average time for one lethal conversion of a base per ribonucleic acid molecule.

The necrotic lesions on Java tobacco are due to mutated particles, and their number is expected to be nearly proportional to their concentration m. If the alteration of a single base is mutagenic, and if the average number of such mutations per ribonucleic acid molecule in the time τ is p, the concentration of such mutants is :

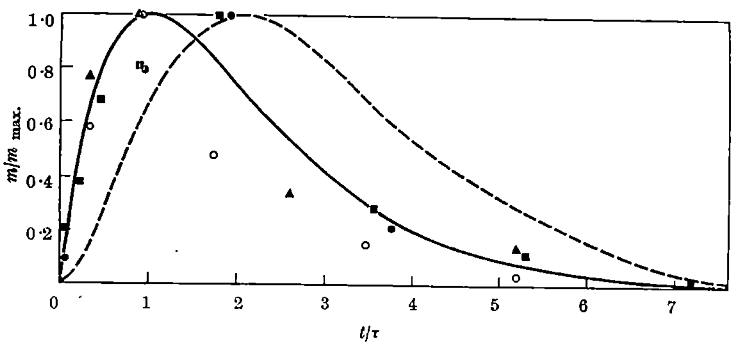

Fig. 1. Dependence of the concentration of mutants (number of necrotic lesions on Java tobacco, relative to maximum value) on the time of incubation with nitrous acid, related to τ. ———, Single-hit curve (equation 3); – – –, double-hit curve; ▲, tobacco mosaic virus *vulgare* (assayed at 0·7 μgm./ml.); ●, ribonucleic acid from tobacco mosaic virus *vulgare* (assayed at 39 μgm./ml.); ■, ribonucleic acid from tobacco mosaic virus *vulgare* (assayed at 19 μgm./ml.); ○, ribonucleic acid from light-green strain *B*11 (assayed at 9·5 μgm./ml.)

$$m = n_0 p \frac{t}{\tau} \exp(-t/\tau) = np\frac{t}{\tau} \qquad (2)$$

or in terms of the maximum value of m:

$$\frac{m}{m_{\text{max.}}} = e\,\frac{t}{\tau}\exp(-t/\tau) \qquad (3)$$

Fig. 1 represents measurements under different conditions with tobacco mosaic virus and with ribonucleic acid derived from two strains. For each case, τ was determined experimentally, using equation (1). The numbers of necrotic lesions on Java tobacco, divided by the maximum value reached in time t, were plotted against t/τ. The experimental results were in agreement with the theoretical relation (3).

The results lead to the following conclusions.

(1) Ribonucleic acid and tobacco mosaic virus treated with nitrous acid give rise to a much larger number of necrotic lesions on Java than untreated material assayed at the same concentration; it is twenty times the spontaneous level when total infectivity has dropped to only half the original value (Table 1). This appearance of mutants at low rates of inactivation excludes selection, and cannot be due to pre-existing mutants, or to mutants arising in the plant.

(2) The mutagenic effect on tobacco mosaic virus and on its isolated ribonucleic acid is equal when the fraction of bases altered in the ribonucleic acid, measured by t/τ, is the same. Also, tobacco mosaic virus treated with nitrous acid has the same proportion of mutants as ribonucleic acid isolated after the treatment. Thus, the mutants are produced by chemical reactions with ribonucleic acid rather than by aggregation phenomena, or by changes in the protein.

(3) The production of mutants is at first linear with t and follows a single-hit curve, irrespective of varying conditions (Fig. 1). Therefore, alterations of single nucleotides are mutagenic.

At $t = \tau$, where one out of about 3,000 nucleotides is altered[3], 6 per cent of the primary infections on Java plants infected with *vulgare* are found to be necrotic (Table 1). If the plating efficiency is assumed to remain unchanged upon mutation, the alteration of any one out of 180 of the total 6,000 nucleotides in the ribonucleic acid strand would be mutagenic, leading to necrotic lesions on Java; this assumption may be subject to later correction.

(4) A variety of other mutants is also produced by nitrous acid. In order to detect them, we isolated individual lesions produced by ribonucleic acid treated with nitrous acid on Xanthi tobacco ($t/\tau = 5 \cdot 2$, Table 1) and assayed them on Java and Samsun plants. Out of 60 lesions, 20 produced no infection, 33 led to a variety of altered symptoms and only 7 gave apparently unchanged symptoms on Samsun tobacco. The altered symptoms proved genetically stable in a transfer experiment. From a control dilution of untreated ribonucleic acid, 64 out of 65 lesions produced infection and no altered symptoms were detected.

We are led to conclude that the chemical alteration of individual bases of the ribonucleic acid molecule *in vitro* is mutagenic. A variety of different mutants may be produced in this way. It remains undecided which of the three types of chemical change caused by the nitrous acid (see above) are mutagenic, and how the chemically altered ribonucleic acid is related to its progeny. In the case of a conversion of cytosine into uracil, it is conceivable that the altered ribonucleic acid undergoes identical reproduction in the host cell.

We are much indebted to Prof. G. Melchers for generous support and advice, and to Prof. G. Schramm and Dr. H. Schuster for helpful discussions. A detailed account of this work is being published in the *Zeitschrift für Vererbungslehre*.

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Correlated Failure of Synthetic Activities in a Wheat Chromosome

The process of chromosome condensation during meiotic prophase, with its uniformity and synchronization of all parts of the nucleus, provides evidence in support of the genotypic control of chromosome behaviour. So characteristic is this co-ordinated development that any exceptions to it have been considered as due to a basic differentiation of chromosome material into euchromatin and heterochromatin[1]. I have, however, shown recently[2] that the normal synchronized condensation of chromatin threads in the pollen mother cells of perennial ryegrass can be induced to break down by experimental means. This and the other induced changes which affect nucleolus organization have provided evidence pointing to a common control of metabolic activities in chromosomes. In the present experiment, the uniformity characterizing the behaviour of chromosomes in bread wheat has been observed to break down, though the techniques involved here are of a very different nature.

In the New Pusa wheat variety 797, meiosis is entirely regular except for the occurrence in some of the plants of one or rarely two small chromosome fragments in many of their pollen mother cells. Ahuja (personal communication, 1957), who analysed a large number of plants, found that the "fragments nearly always lie away from the nucleolus". Neither the pollen fertility nor the regular behaviour of chromosomes, however, is found to be affected because of the presence of fragments which obviously owe their origin to spontaneous chromosome breakage. During the course of some mutation-breeding experiments, a number of seeds of this variety were treated with an X-ray dose of 10,000 r. (50 kV.) after soaking in water for 24 hr. The X_2 progeny raised from one of these seeds consisted of plants having one or more fragments in their pollen mother cells, some of them also having a multiple association resulting from reciprocal translocations of chromosomes.

In a number of plants showing such breakage, either a single fragment or two were found to be closely associated with the nucleolus in a very large number of cells (Fig. 1). The consistency with which this association was observed naturally suggested that the nucleolar-organizing region of one of the nucleolar chromosomes might be forming part of the fragment. The suggestion is supported by the presence of a constriction in it and also of a heteromorphic bivalent close to the nucleolus which, however, is not always clearly seen. It is further supported by observations on the root-tip chromosomes of X_3 seedlings, some of which show the presence of only three chromosomes with secondary constrictions in their nuclei (Fig. 2), in contrast to the four invariably found in the control material.

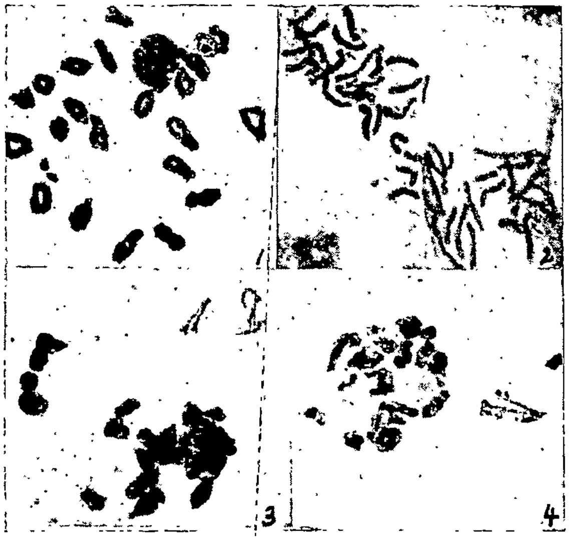

Fig. 1. 1, Pollen mother cell with two constricted fragments, one attached to the nucleolus. Of the 21 II, one close to nucleolus appears heteromorphic. 2, Root-tip cell showing the presence of only three chromosomes with secondary constrictions. 3, An affected pollen mother cell at diakinesis with one of its chromosomes uncondensed. 4, Another cell showing a fragment associated with the nucleolus and two univalents, one of which is retarded. 1,3,4, Carnoy-acetocarmine squashes (× 770, 816, 810); 2, Feulgen squash (× 630)

The organization of the nucleolus by the organizer-carrying fragment is scarcely of any great significance in itself; it was found, however, in a number of plants showing such organization, that either a single chromosome or a pair are retarded in their prophase condensation in a few of the pollen mother cells. This non-synchronized development results in the presence in the same nucleus of chromosomes which present a highly condensed appearance typical of metaphase, and one or two others which are relatively unspiralized, showing poor stainability both with carmine and the Feulgen stains (Figs. 3 and 4). The retardation affects only one of the 21 chromosome pairs and then only in few of the pollen mother cells.

It is not possible from the present observations alone to establish clearly the identity of the chromosome which shows retarded development. The earlier work on rye grass[2], however, strongly suggests that it must be the one which has its nucleolar-organizing region removed by breakage. In rye-grass, it has been shown that following high-temperature treatment, the nucleoli are organized adventitiously on each of the seven chromosomes. If, however, one or more of them fail to take part in nucleolar synthesis, they are invariably retarded in their prophase development. In the case of wheat, it is reasonable to suppose that a chromosome which has a particular site in it differentiated for the formation of nucleolus, may suffer in the synthesis of nucleolar material in the absence of this region; even though it is obvious from the work on rye-grass as well as from other studies[3,4] that an organizer is not always indispensable for nucleolar formation, its main function probably being to collect materials from all other chromosomes also rather than to synthesize them exclusively.

If it is accepted that the retarded chromosome in wheat is invariably the one which fails in its nucleolar synthesis in the absence of its organizing region, it follows that nucleolar formation and chromosome condensation are related phenomena. Since the prophase condensation of chromosomes is known to be conditioned by deoxyribonucleic acid—the Feulgen reaction of the affected chromosome is in agreement with this—the argument can be extended to suggest that the synthesis of deoxyribonucleic acid and nucleolar material in a chromosome are closely correlated.

A possible explanation of this relationship is suggested by the observations of Caspersson[5], Beermann[6] and others, which indicate that the nucleolar material represents the accumulated primary gene products. It is not unlikely that the factors which affect the capacity of the genic material to synthesize its primary products at telophase would also affect its own reproduction during later stages.

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Transmission of Phenotypic Variability within a Pure Line

IN the course of a study of the genetic and environmental factors controlling heat resistance in peas (*Pisum sativum*), it was found that when the source of pollen was non-uniform with respect to the environment under which it was developed, the F_1 population exhibited a variance in growth which exceeded considerably that of either parent. Upon analysis of the results it was found that the excessive variance could be attributed entirely to the difference among the environments of the different pollen sources. This suggested that there may be a carry-over by the pollen of environmental influences on the pollen parent.

Two inbred lines of peas were used in these experiments, both lines having been inbred since the early 1930's. It is therefore most likely that these two lines, which have gone through an intensive inbreeding and selection programme extending for some 20–25 years, are for all practical purposes homozygous. All the experiments were performed in the Earhart Plant Research Laboratory. A description of this Laboratory and the experimental facilities available in it has been given by Went[1].

The seeds of both varieties were planted in either constant temperature – artificial light chambers, or in controlled fluctuating temperatures in greenhouses with natural light supplemented by artificial light to make a 16-hr. photoperiod. The temperature fluctuation of the greenhouse consists of a constant temperature during the day period and a constant but lower temperature during the night period.

Crosses were made between the two varieties used in these experiments and within each variety. The crosses were made in the following manner. The plants used as females were grown in a greenhouse with 16-hr. photoperiod and a controlled day temperature of 20° C. and a night temperature of 14° C. These plants were pollinated with pollen from plants growing in different constant temperatures. The F_1 progenies from these crosses were grown at 26° C., 16-hr. photoperiod, to test for heat resistance. It was during this phase of the experiments that differences in the growth characteristics among members of the F_1 population were observed. These differences are related to the temperatures in which the pollen donors had grown.

Table 1 summarizes the results of one experiment and shows the manner in which the crosses were made. A significant difference among pollen sources is shown by the significant differences in the growth behaviour of the three different groups.

Table 2 is a summary of the analysis variance of four separate experiments. In each experiment the contribution to the total variance caused by differences in pollen source, is significant.

Table 1. THE EFFECT OF GROWTH TEMPERATURE OF THE POLLEN-DONOR ON THE GROWTH CHARACTERISTICS OF THE F_1 PROGENY GROWN AT 26° C. ALL PLANTS GROWN ON A 16-HR. PHOTOPERIOD. FEMALE PARENTS GROWN AT 20° C. DURING LIGHT PERIOD, 14° C. DURING DARK PERIOD

Pollen-donors grown at: Deg. C. during light period	Pollen-donors grown at: Deg. C. during dark period	Growth of F_1 progeny: No. of nodes formed	Growth of F_1 progeny: Growth-rate (cm./day)	Growth of F_1 progeny: Final height (cm.)
20	14	14	0·544±0·018	7·68±0·18
14	14	11·6	0·609±0·016	8·45±0·10
26	26	12	0·679±0·032	9·38±0·24

Table 2. ANALYSIS OF VARIANCE
Summaries showing effects of differences in growth temperatures among pollen parents on the growth-rates of their progeny

Source	Exp. I Unica × Unica d.f.	Exp. I Unica × Unica M.S.	Exp. II Unica × L_5 d.f.	Exp. II Unica × L_5 M.S.	Exp. III L_5 × L_5 d.f.	Exp. III L_5 × L_5 M.S.	Exp. IV L_5 × Unica d.f.	Exp. IV L_5 × Unica M.S.
Between pollen sources	3	2·67*	2	3·19*	4	1·51†	1	6·48*
Within pollen sources	20	0·32	9	0·16	20	0·49	7	0·27

* Significant at 1 per cent level. † Significant at 5 per cent level.

These experiments, along with others[2] which have shown that differences can be produced in the growth characteristics of pea plants as a result of the effect of the environment on previous generations, are remarkably similar to those reported by Durrant[3] in flax.

Further studies of the relationship between the previous environment and the effect on the progeny are in progress and will be reported in due course. This work was supported by a grant from the National Science Foundation, Grant No. G1385.

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Silicification of Branched Cells in the Leaves of *Nardus stricta* L.

ATTENTION has been directed[1] to the presence of certain peculiar branched rods of opaline silica in the leaves of *Nardus stricta* and in the soils on which this species grows. Although transverse sections of leaves of *N. stricta* figured by Grob[2] and Hegi[3] show what are apparently the minute hat-like opals which we have detected even in the very young leaves, we have found no reference depicting or describing the branched rods which we detect in surface preparations of older leaves after rendering them transparent, for example, by controlled treatment with chromic acid (Fig. 1). The branched cells which secrete these bodies, although not present in the seedling leaves, develop later on the well-marked ribs of the upper surface (Figs. 2 and 3), and their protruding portions can be identified with what have been described as asperities[4] or papillæ[2]. The protrusions tend to be longest near the crest of the rib, diminishing laterally to give every gradation from well-branched to unbranched long cells (Figs. 4 and 5).

This structure, with its end-to-end arrangement of long cells, is quite distinct from those involving the common types of trichome, and although we have examined many species of grasses we have seen it only in *N. stricta*. Stebbins[5] suggests that a distinctive genus such as *Nardus*, with its single species, may represent the last remains of some evolutionary line now almost extinct, or the culmination of a trend which has been successful in one specialized sphere. If it should be confirmed that no other grass besides *N. stricta* exhibits these branched cells and branched opaline bodies, it would give additional support to such theories.

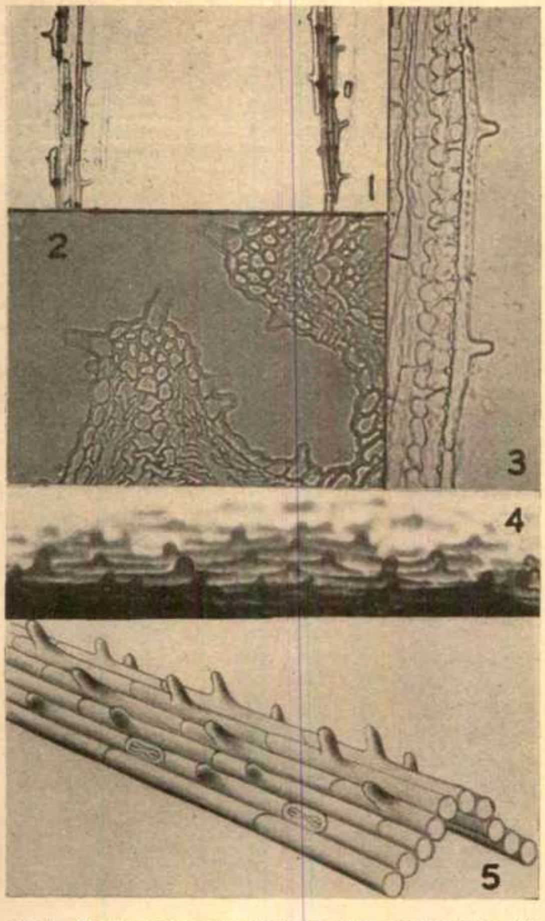

Fig. 1. *Nardus stricta*. Branched rods of opal in two ribs of the upper surface of the leaf (× 100). Fig. 2. Transverse section (× 270). Fig. 3. Longitudinal section (× 270). Fig. 4. Rows of branched cells in one rib, darkened by chromic acid treatment (× 220). Fig. 5. Diagrammatic representation of surface cells in one rib

The progressive silicification of *Nardus* leaves is being further investigated with material collected at intervals throughout the year. The special techniques used in this work have already been described[6].

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Alary Polymorphism in the Gerroidea (Hemiptera Heteroptera)

THE Gerroidea exhibit a marked alary polymorphism which has promoted many investigations since that of Poisson[1], who classified the various forms and attempted to investigate the genetics of this polymorphism by breeding experiments. This lead was followed by Ekblom[2] and Guthrie[3] without reference to Mitis[4], who had suggested a possible link between life-cycles and polymorphism. These breeding experiments have given varied and confusing results, and one may only conclude that any form can give rise to any other and that, as Guthrie[3] decided, the problem is not one of simple genetics.

In a recent study of the biology of *Gerris* and *Velia* species, I have been able to extend the observations made by Mitis[4], illustrating a close relation between life-cycle, habitat and polymorphism[5]. Only bivoltine species were seen to be polymorphic, the univoltine species being predominantly monomorphic. Of the univoltine species, *Gerris najas* (Deg.) and the *Velia* species are most commonly apterous and usually inhabit running water, whereas the monomorphic univoltine species inhabiting ponds and pools (*G. costai* (H.-S.), *G. gibbifer* Schum.) are mostly macropterous. In these instances it seems that the needs of distribution have determined the form of the single generation. Poisson[1] showed that short-winged forms were more abundant in the summer, and I have found that they are restricted to the summer generation in most cases. *G. argentatus* Schum., *G. odontogaster* (Zett.) and *G. thoracicus* Schum. exhibit an alternation between a macropterous overwintering generation and a polymorphic summer generation, while *G. paladum* appears to have an entirely short-winged summer generation. Two further species (*G. lacustris* (Linn.) and *G. lateralis* Schum.) resemble *G. odontogaster* but have in addition a small proportion (less than 10 per cent) of short-winged forms in the over-wintering generation.

All these species spend the winter months on land as adults, flying to and from over-wintering sites in the autumn and spring respectively. Having established themselves on suitable habitats these insects then resorb their wing-muscles and breed, producing in most instances a mixed generation of long- and short-winged forms. The species that do this occupy small ponds, pools and ditches or limited areas of lake-fringes. Since short-winged forms contain the same number of eggs as long-winged forms, and they both grow at the same speed[5], the usual theories of the significance of short-wingedness are no longer adequate. Instead I wish to stress the inability of short-winged forms to fly—an obvious but neglected point of view. It has been noted that long-winged forms lose their powers of flight after over-wintering and before breeding, as in many insects. The following generation consists of approximately equal numbers of flightless forms, which maintain the breeding population on the pond on which the species has already bred successfully, and alate forms which are capable of migration if the pond becomes either over-populated or a poor habitat (due to surface pollution, drought, etc.). In this context it should be recalled that *G. paludum* has an entirely short-winged summer generation, but inhabits the open water of lakes and large ponds and is not therefore exposed to the same selective pressures as described above. The alternation of a long-winged and a polymorphic or short-winged generation reflects the alternation of habitats occupied by the insects.

Ford[6] described three ways by which a balanced polymorphism such as this could be maintained: switching by simple genic segregation (as in *Sitona*[7]), selective predation alternately favouring one form and then the other, where both forms are produced in each generation (as in *Adalia*[8]), or by the switching of a gene complex by environmental factors. Mather[9] regarded the last method as the simplest system which could produce the situation in which types "successively vanish and reappear in a population", as I have observed to occur in these insects.

This approach to an old problem will be described in greater detail elsewhere, but it would seem that the results of previous breeding experiments must be largely discounted on the grounds that the offspring produced from any one form varies from one generation to the next, and most authors combine the results of breeding experiments made throughout the season. As the polymorphic form resulting from each breeding is probably influenced by the environment, the laboratory conditions should be carefully controlled. We are now in a position to select a species with a distinct 'alternation of generations' and attempt to operate the switch mechanism by such controlled breeding.

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Carbon Dioxide Fixation in Germinating Pine Pollen (*Pinus ponderosa*)

CARBON dioxide fixation by plant tissues other than those involved in photosynthesis has recently been reported for whole plant tissues and cellular particulates of roots[1,2]. This communication reports observations on the incorporation of carbon dioxide into the organic acid, amino-acid, and protein fractions of germinating pine pollen.

Pinus ponderosa pollen was germinated for 15 hr. at 29° C. in 0·01 *M* calcium–potassium phosphate buffer, *p*H 5·9, in the presence of the fungistat – bacteriostat mixture 'Mysteclin' (an antibiotic – antifungal mixture composed of tetracycline and mystatin; kindly supplied by the Medical Division, E. R. Squibb and Sons, New Brunswick, New Jersey). Radioactive potassium bicarbonate was added, and then the mixture was shaken for 1 hr. in a Warburg flask at 25° C. The reaction was stopped by acidification and the excess carbon dioxide removed by bubbling through inert carbon dioxide for 15 min. The mixture was then centrifuged and the supernatant removed from the pollen residue.

Table 1. PERCENTAGE OF CARBON-14 DIOXIDE INCORPORATED BY *Pinus ponderosa* POLLEN

Experiment	In supernatant		
	Total	Ether extract	Alcohol extract
1	24·6	11·2	2·1
2	34·1	13·1	3·4

Reaction mixture contained 200 mgm. pollen germinated 15 hr., 29° C.; 0·8 mgm. 'Mysteclin' in 0·002 *M* potassium phosphate buffer, *p*H 5·9. 0·5 μmoles potassium bicarbonate containing 125,000 counts/sec. was added after equilibration. The side-arm contained 0·5 ml. 2 *N* sulphuric acid added after 1 hr. incubation. Total volume, 2·5 ml.; temperature, 25° C.; incubation time, 1 hr.

Table 2. EFFECT OF PHOSPHOENOLPYRUVATE ON CARBON-14 DIOXIDE FIXATION BY GERMINATING POLLEN (*Pinus ponderosa*)

*p*H	Treatment	Percentage carbon-14 dioxide activity incorporated into	
		Supernatant	Residue
4·8	Heat inactivated	0·3	0·0
	Without phosphoenolpyruvate	9·0	0·6
	With phosphoenolpyruvate	10·7	0·5
7·4	Heat inactivated	0·3	0·0
	Without phosphoenolpyruvate	11·8	0·7
	With phosphoenolpyruvate	13·8	0·7

Reaction mixture the same as under Table 1 except 7 mgm. phosphoenolpyruvate was added where indicated; 90 μmoles phosphate buffer in each individual flask.

The total amount of radioactive carbon dioxide incorporated was determined by measuring the activity in aliquots of the supernatant and the residue. An ether extract and an alcohol extract of the reaction mixture were prepared. Activities in each of these fractions were ascertained by plating and counting in a windowless flow counter.

Table 1 indicates that most of the carbon-14 dioxide incorporated was in acid- or water-soluble components in the supernatant solution. After 1 hr. incubation, carbon-14 dioxide incorporated was higher in the organic acid fraction extractable in ether than in the alcohol-soluble components of the pollen supernatant.

Since many studies have indicated the presence of phosphoenolpyruvate carboxylase in plant tissues[3], the capacity of phosphoenolpyruvate to increase the incorporation of carbon dioxide by the pollen was investigated.

As Table 2 shows, carbon dioxide fixation increased when phosphoenolpyruvate was added to the incubating solution. About the same increase occurred whether the incubating medium was at the optimal *p*H of the phosphoenolpyruvate carboxylase or closer to the physiological *p*H. This agreement may be due to the high internal buffering capacity of the whole cell. The optimum *p*H for *P. ponderosa* pollen germination is 5·9, and germination is inhibited below *p*H 5·0 and above *p*H 7·0. This fact probably explains the total lower incorporation in the results shown in Table 2 as compared with those in Table 1. The stimulation due to phosphoenolpyruvate noted in particulate preparations[2] was much larger than that observed here. Since the inherent levels of phosphoenolpyruvate in pollen are quite high, perhaps alternate mechanisms of carbon dioxide fixation exist in germinating pollen or the treatment procedure used may not be optimal.

The pollen residues, which were insoluble in alcohol and ether, were hydrolysed overnight in 6 *N* hydrochloric acid at 117° C. Two-dimensional paper chromatograms were prepared of the alcohol extract of the hydrolysate using phenol/water and butanol/propionic acid/water as the solvents. The radioautographs showed activity in serine, aspartate, glutamate and malate. Radioautographs of the ether extract of the supernatant showed activity in malate, in what appeared to be citrate and in another organic acid.

The net synthesis of labelled amino-acids and possibly protein by germinating pollen, as evidenced by the hydrolysate studies, indicates that pollen on germinating into the female tissue not only absorbs water and activates inherent enzyme systems but probably can also synthesize the protein constitutive units of enzymes. Since pollen generally grows in a highly anaerobic environment, the capacity of pollen to incorporate carbon dioxide and synthesize amino-acids, proteins and possibly cell-wall materials may be an important growth mechanism in the plant reproductive cycle. The reduction and incorporation of carbon dioxide, coupled with the oxidation of carbohydrates present in the female gametophyte tissue, may in part be the mechanism by which rapid tube elongation can occur in pollen grains with only very limited carbon substrates.

This study was supported in part by grants from Resources For the Future, Inc., and the National Science Foundation.

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Effect of the Cotton Plant in the Sudan Gezira on Certain Leaf-feeding Insect Pests

COTTON in the Sudan Gezira, where some 240,000 feddans (1 feddan = 1·034 acres) of *Gossypium barbadense* L. are grown by gravity irrigation from the Sennar Dam, is attacked, particularly during the first 3½ months of its growth, by three important leaf-feeding insects, namely, the jassid, *Empoasca libyca* de Berg.; whitefly, *Bemisia tabaci* Gen. and thrips, *Hercothrips fumipennis* Bag. and Cam.[1]. These insects may cause important loss in yield of seed cotton[2], but their intensity of attack varies from season to season[2,3]. If, however, application of control measures is delayed until damage is easily visible, yield benefit from such control may be seriously reduced[2]. An object of entomological research is prediction of outbreaks of economic significance.

One cause of the seasonal variations in numbers was elucidated recently by a study of the effect of nitrogenous fertilizer on these pests. In an experiment in which 1 N. or 2 N. (where 1 N. is equivalent to 45 rotls of nitrogen; 1 rotl = 0·99 lb.) per feddan as ammonium nitrate was applied to cotton at different dates during the first 3½ months after sowing, it was found that the estimated Kjeldahl nitrogen in the dry matter of the foliage of plants receiving fertilizer was greater than in those not receiving fertilizer. Nevertheless, there was a tendency in all investigated treatments for the concentration of leaf nitrogen to fall as the season progressed, while infestations of jassids and whitefly increased with time. When, in an analysis of covariance, these latter effects were eliminated, a highly significant regression of jassid and whitefly densities on concentration of leaf nitrogen could be demonstrated. This finding is reminiscent of the work of Allen and Selmon[4] on *Phaedon cocleariae* F., and Le Roux[5] on *Tetranychus bimaculatus* Harvey, to quote two recent examples, and it is believed to be due to an increase in birth-rate with increased concentration of leaf nitrogen.

Table 1. MEAN NITROGEN CONCENTRATION IN COTTON LEAVES (PER CENT OF DRY WEIGHT) IN FIVE SAMPLES TAKEN BETWEEN EARLY SEPTEMBER AND LATE OCTOBER DURING FOURTEEN SEASONS

Locality	0 N. plots	3 N. plots	Mean
Hag Abdulla (south)	3·51	3·70	3·60
Gezira Research Farm (centre)	3·70	3·84	3·77
Turabi (north)	3·87	3·98	3·93
Mean	3·69	3·84	3·76

	Sites	Nitrogen
S.E.	±0·049	±0·059
Least sig. diff.		
($P = 0·05$)	0·14	0·17
($P = 0·01$)	0·18	0·22

Examination of results obtained by the Research Division on concentration of leaf nitrogen at three Gezira sites over fourteen seasons gave the means shown in Table 1.

The concentration of leaf nitrogen was affected by locality and fertilizer treatment. The effect on the two main Gezira cotton varieties, namely, *X*1730*A*, grown in the south, and Domain Sakel, grown in the north, was insignificant. There were also highly significant seasonal differences. Because of the established effect on Gezira cotton yields[6] of rains falling between July 1 and August 15 (pre-sowing rains) the covariance of concentration of leaf nitrogen on these rains was examined during the six seasons when all the cotton had been sprayed with DDT. The correlation coefficient of concentration of leaf nitrogen on pre-sowing rains was $-0·5842$ which, for 22 degrees of freedom, is highly significant. There was evidence, however, that the effect was not direct, and seasonal variation in concentration of leaf nitrogen was caused by some uninvestigated factor itself correlated with rainfall.

The regression of the mean September and October concentration of nitrogen in the leaf material of the cotton plant on pre-sowing rains could be expressed by the equation:

$$X_2 = 4·07 - 0·0031X_1$$

where X_2 is the mean concentration of leaf nitrogen during September and October (as percentage of dry matter), and X_1 is the rainfall in mm. during July 1–August 15. The standard error of the regression coefficient is $\pm$ 0·0009).

The seasonal incidence of pests feeding on the leaves was recorded during four seasons at one site (Gezira Research Farm), and was found to be correlated with pre-sowing rains and the concentration of leaf nitrogen. The regression equation for rate of jassid increase is:

$$a = 18·03 - 0·071X_1\ (\pm 0·010)$$
$$a = 10·96X_2\ (\pm\ 0·69) - 35$$

where a is the mean rate of increase in jassid nymphs per 100 leaves per day

(other symbols as before, with standard errors of regression coefficients in brackets). This describes the rate of increase during September and October before spraying as well as that during October and November after DDT spraying.

The mean infestations during October and November, namely, after spraying, and at a time when the pests are considered to exert most effect on crop yields, were:

$$\text{Jassids}: \; Y_1 = 156{\cdot}4X_2 - 478 \; (\pm 20{\cdot}4)$$
$$\text{Whitefly}: \; Y_2 = 9{\cdot}71X_2 - 0{\cdot}27 \; (\pm 0{\cdot}17)$$
$$\text{Thrips}: \; Y_3 = 4{\cdot}16X_2 - 0{\cdot}89 \; (\pm 3{\cdot}17)$$

where Y_1 is the mean number of nymphs of *E. libyca* per 100 leaves, Y_2 is the mean number of adults of *B. tabaci* (logarithm), and Y_3 is the percentage of leaves infested with larvæ of *Hercothrips* sp. (arc sin/percentage) (other symbols as before).

The regression coefficients for whitefly and jassid infestations were highly significant: that for thrips was not significant.

E. libyca is preyed upon by the Mymarid egg parasites *Anagrus* sp. and *Paranagrus* sp. while the *Aphelinid* parasites *Eretmocerus* sp. and *Prosaptella* sp. cause heavy mortality of the later instars of *B. tabaci*. All these parasites appear to be more numerous in seasons of good than of poor pre-sowing rains, but statistical evidence is deficient.

The results, although incomplete, raise the interesting possibility that the cotton plant in the Sudan Gezira may, by the seasonal changes in composition of its foliage expressed by percentage of Kjeldahl nitrogen, influence the rate of increase of some of its leaf-feeding insects in such way as to enable them to 'break away' from biological controlling agents. According to F. Crowther[7] the concentration of nitrogen in cotton leaves is determined by: (1) the concentration of nitrogen in the soil and (2) the rate of development of the plant. Jewitt[8] showed that the nitrate-nitrogen in Gezira soils was negatively correlated with pre-sowing rains. The results so far available do not indicate that rains control leaf nitrogen directly, but determine it through other correlated factors influencing the early rate of development of the cotton plant.

It is hoped that this knowledge, considered in relation to some other aspects of the ecology of the pests concerned, will enable prediction to be made of pest outbreaks in the Sudan Gezira before the crop is sown. A full account of this approach in relation to the cotton jassid will be published elsewhere.

I am grateful to Sayed Ahmed Kordofani, of the Research Division, for access to his records of the growth and composition of the cotton plant in the Sudan Gezira, and to the Chief of Agricultural Research, Ministry of Agriculture, Sudan Republic, for permission to publish this work.

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Bat Erosion as a Factor in Cave Formation

I have read with much interest the communication by W. A. King-Webster and J. S. Kenny[1] in which it is suggested that roosting bats can play a considerable part in cave excavation where the rock is soft. In particular, reference is made to the existence, in the roof of a limestone cave in Mt. Tamana (Trinidad), of bell-shaped cavities ranging in depth from 3 ft. to 6 ft., and in diameter at the mouth from 1½ ft. to 2½ ft., and which are used by sleeping bats. The suggestion is made that the habit of the bats of alighting at the lower edge of the bell and then jostling upwards into a central position, by continuation over innumerable years, has led to the excavation of these cavities, with maximum removal of rock at the mouth of the bell.

Ceiling cavities of the type described are, however, a commonplace feature in many limestone caverns and indeed in portions of those caverns that have never been known to have been used by bats. This applies particularly to tunnels so far in linear distance from the cave entrance or in depth below it that they are beyond the normal zone of penetration of the bats. Such ceiling pockets, and also similar indentations in cave walls, have been described by Bretz in his classic paper[2], in which he elaborates on the theories, originally proposed by Davis[3], concerning the phreatic origin of certain types of cave tunnels and systems. Bretz specifically quotes such wall and ceiling pockets as examples of cave features of phreatic origin, pointing out that it is difficult to visualize their formation by any solution mechanism under conditions whereby there was an air space above the water surface. He therefore considers that such ceiling pockets were formed below the lowest normal water-table level (such as might occur at times of drought) and he directs attention to the fact that if the 'eating-out' process is continued long enough, adjacent pockets merge into one another, thus producing one of the effects described by King-Webster and Kenny.

During the course of the studies made by my wife and myself on the habits of certain cave-dwelling bats[4], in particular, the greater horseshoe bat (*Rhinolophus ferrumequinum*), we have often noticed ceiling pockets, of the type described above, in the natural caverns that exist in scattered outcrops of Devonian limestone, in the neighbourhood of Buckfastleigh in Devon. Some of these pockets are commonly used during the winter months by the greater horseshoe bats, probably because such dome-shaped cavities provide areas of roof that are free from draughts. It is, however, important to note that these caves were only revealed as a result of quarrying operations during the past century, and they were thus not occupied by bats until they were opened to the outside world, barely a hundred years ago. Although we have evidence in Devon that the claws of a greater horseshoe bat can mark the roof of a cave, at least to the extent of scratching off powdery surface deposits from the limestone, it would be surprising indeed if the colonies of bats could have excavated roof pockets to a depth of several feet in such a limited time. I therefore feel that although the 'bat erosion' effect postulated by King-Webster and Kenny may well occur with certain types of limestone, it represents at best only a secondary, and probably minor, contribution to the shape and size of the ceiling pockets described.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 24

Royal Geographical Society (at 1 Kensington Gore, London, W.7), at 5 p.m.—Lieutenant C. J. Wynne-Edwards, R.N.: "Hydro- aphic Survey in the Falkland Islands Antarctic Dependencies".

British Society for the History of Science (in the Council om of the Science Museum, Exhibition Road, South Kensington, ndon, S.W.7), at 5.30 p.m.—Dr. G. J. Whitrow: "The Evolution Our Numerals and System of Numeration".

Institution of Electrical Engineers, Radio and Telecom- nication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.— . J. S. Seeley and Dr. J. Brown: "The Use of Dispersive Dielectrics a Beam-Scanning Prism"; Dr. J. S. Seeley: "The Quarter-Wave tching of Dispersive Materials"; Mr. A. Carne and Dr. J. Brown: heory of Reflections from the Rodded-Type Artificial Dielectric".

University of London (in the Anatomy Theatre, University llege, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. C. A. gers: "Packing and Covering".* (Inaugural Lecture.)*

Royal Aeronautical Society (at the Institution of Civil Eng- ers, Great George Street, London, S.W.1), at 6 p.m.—Mr. J. E. teman: "Inertia Guidance".

Tuesday, November 25

Institution of Chemical Engineers (at the Geological Society· rlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. H. E. se: "A Suggested Equation Relating to the Mixing of Powders d its Application to the Study of the Performance of Certain Types Machine".

University of London (at the London School of Hygiene and opical Medicine, Keppel Street, Gower Street, London, W.C.1), 5.30 p.m.—Dr. E. H. Mercer: "Electron Microscopy and the ructure of the Living Cell".* (Eighth of eleven lectures on "The ientific Basis of Medicine" organized by the British Postgraduate edical Federation. Further lectures on November 27 and December and 4.)

Society of Instrument Technology, Data Processing Section t Manson House, Portland Place, London, W.1), at 6 p.m.—Mr. . C. M. Barnes: "Digital Data-Recording for Nuclear Experiments".

Society for Analytical Chemistry, Physical Methods Group t the Chemical Society, Burlington House, Piccadilly, London, .1), at 6.30 p.m.—Fourteenth Annual General Meeting, followed meeting on "Modern Methods of Purification".

Wednesday, November 26

University of London (at the Postgraduate Medical School of ondon, Ducane Road, London, W.12), at 2 p.m.—Dr. H. M. Sinclair: Essential Fatty Acids".*

Geological Society of London (at Burlington House, Piccadilly, ondon, W.1), at 5 p.m.—Mr. Graham F. Elliott: "Fossil Calcareous lgal Floras of the Middle East"; Miss Leonora A. Stevens: "The terglacial of the Nar Valley, Norfolk" (paper communicated by r. R. G. West).

Royal Geographical Society (at 1 Kensington Gore, London, .W.7), at 5 p.m.—Prof. Max Mallowan: "Excavations at Nimrud, 958".

Institute of Marine Engineers (at the Memorial Building, 3 Mark Lane, London, E.C.3), at 5.30 p.m.—Sir John Cockcroft, .M., F.R.S.: "Recent Advances in Nuclear Engineering" (Sir harles Parsons Memorial Lecture).

Institution of Electrical Engineers, Supply Section (at avoy Place, London, W.C.2), at 5.30 p.m.—Dr. L. L. Alston and rof. F. M. Bruce: "Investigations of Power-Follow Current Phe- omena using a Synthetic Power Source"; Dr. L. L. Alston: "The mpulse Initiation of Arc Discharges".

British Institution of Radio Engineers (at the London School f Hygiene and Tropical Medicine, Keppel Street, Gower Street, ondon, W.C.1), at 6 p.m.—Annual General Meeting. 7.15 p.m.— rof. E. E. Zepler: Presidential Address.

Society of Chemical Industry, Food Group (at 14 Belgrave quare, London, S.W.1), at 6.15 p.m.—Scientific Papers.

British Psychological Society, Medical Section (at the Royal ociety of Medicine, 1 Wimpole Street, London, W.1), at 8.30 p.m.— r. John Bowlby: "Studies of Parent–Infant Interaction in Man nd Animals—some Notes on Projects in Progress".

Thursday, November 27

Institute of Physics, Electron Microscopy Group (at the Royal ociety of Arts, John Adam Street, Adelphi, London, W.C.2), at 0 a.m.—Meeting on "Electron Staining".

University of London (at the London School of Hygiene and ropical Medicine, Keppel Street, Gower Street, London, W.C.1), at .30 p.m.—Mr. Michael Abercrombie: "Cell Surface and the Control f Growth".* (Ninth of eleven lectures on "The Scientific Basis of ledicine" organized by the British Postgraduate Medical Federation. urther lectures on December 2 and 4).

Friday, November 28

Institute of Physics, Electron Microscopy Group and X-Ray nalysis Group (at the Institution of Civil Engineers, Great George treet, London, S.W.1), at 10 a.m.—Joint Conference on "Precipita- ion in Alloys".

Institute of Rural Life at Home and Overseas (at Friends International Centre, 32 Tavistock Square, London, W.C.1), at 1.15 p.m.—Mr. George Bredin: "The Impact of the Gezira Cotton-Growing Scheme on the Rural Population of the Blue Nile".*

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Turbidity Currents: High Speed Underwater Flow of Sediment Suspensions". Chairman: Dr. G. E. R. Deacon, F.R.S. Speakers will include Dr. A. S. Laughton, Dr. R. Stoneley and Dr. T. H. Ellison.

Physical Society (in the Large Lecture Theatre, Chemistry Department, Imperial College, Imperial Institute Road, London, S.W.7), at 5 p.m.—Prof. Niels Bohr, F.R.S.: "General Implications of the Atomic Nucleus" (9th (1958) Rutherford Lecture).*

Royal Anthropological Institute of Great Britain and Ireland (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. Sir Wilfrid Le Gros Clark, F.R.S.: "Bones of Contention" (Huxley Memorial Lecture).

Institution of Electrical Engineers, Medical Electronics Discussion Group (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion Meeting on "Problems Encountered in the Field of Neurophysiology".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. J. Z. Young, F.R.S.: "Squids, Cuttlefishes and Octopuses".

Friday, November 28—Thursday, December 4

Electronic Computer Exhibition (at Olympia, London, W.14).*

Monday, December 1—Wednesday, December 3

Business Computer Symposium.

Saturday, November 29

Institute of Physics, X-Ray Analysis Group (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 9.30 a.m. —Scientific Papers.

Botanical Society of the British Isles (in the Lecture Room of the Royal Horticultural Society, Vincent Square, London, S.W.1), at 12 noon—Exhibition Meeting.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer, Grade B (with a degree in electrical engineering or physics and preferably a special knowledge or industrial experience of some branch of the subject), in Telecommunications and Electronics—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (November 28).

Assistant Lecturer (with an honours degree in physics and preferably able to teach the subject to a high standard) in Physics—The Principal, Wigan and District Mining and Technical College, Wigan (December 1).

Lecturer or Assistant Lecturer (with a good honours degree and teaching experience) in Biology at the Royal Technical College of East Africa—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (December 5).

Lecturer (with special qualifications in botany or agricultural botany) in Botany—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (December 5).

Lecturer or Research Assistant in Bacteriology and Virology —The Registrar, The University, Sheffield (December 6).

Research Assistant (preferably with a Ph.D. degree and suitable experience in biochemistry and microbiology) in the Department of Bacteriology, to assist in a programme of work on the immunochemistry of *Bordetella pertussis*—The Registrar, The University, Manchester 13 (December 6).

Senior Lecturer and a Lecturer in Mathematics at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, December 12).

Lecturer (graduate in metallurgy or chemistry with special qualifications in the theory and principles of extraction metallurgy) in Metallurgy—The Registrar, The University, Manchester 13 (December 13).

Senior Lecturer/Lecturer in Chemistry at the University of New South Wales, Sydney, Australia—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (Australia, December 13).

Reader in Aeronautics at Imperial College, London, S.W.7—The Academic Registrar, University of London, Senate House, London, W.C.1 (December 15).

Senior Lecturer (registered pharmaceutical chemist) in Pharmacy at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 15).

Chair of Civil Engineering, Senior Lecturer or Lecturer in Mechanical Engineering, Lecturer in Engineering Mathematics, Lecturer in Civil Engineering, and a Lecturer in Electrical Engineering at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 29).

Chair of Botany—The Registrar, The University, Hull (December 31).

Research Fellow in the Physiology Department, Faculty of Rural Science, University of New England, Australia, to undertake research associated with a study of the comparative physiology of mammalian erythrocytes with particular reference to the physiological significance of individuality in the ruminant erythrocyte—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

LECTURERS or ASSISTANT LECTURERS IN PHYSIOLOGY at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 31).

LECTURER or ASSISTANT LECTURER (preferably with qualifications in mathematical analysis and/or statistics) **IN MATHEMATICS** at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 10).

LECTURER IN PURE MATHEMATICS—The Secretary, Queen's University, Belfast (January 15).

BROTHERTON CHAIR OF CHEMICAL ENGINEERING in the Houldsworth School of Applied Science—The Registrar, The University, Leeds 2 (January 31).

ENTOMOLOGIST (with a good honours degree in zoology and an interest in, and aptitude for, taxonomic work, and preferably experience in the Diptera particularly the Calyptrata) at the Commonwealth Institute of Entomology, London—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (January 31).

BIOCHEMIST (with a Ph.D. degree or equivalent research experience), for work on the metabolism of cell and organ cultures—The Secretary, Strangeways Research Laboratory, Wort's Causeway, Cambridge.

EXPERIMENTAL OFFICER (at least 26 years of age, preferably with a pass degree, or at least H.N.C. (engineering or applied physics) or equivalent), to carry out experiments designed to investigate the mechanical strength of complex assemblies, to instrument parts for experiments and to analyse experimental results—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. A.1895/34.

PHYSICAL CHEMIST, PHYSICIST or METALLURGIST, for research on anodic oxide films—Dr. G. M. Shrum, Director, British Columbia Research Council, University of British Columbia, Vancouver 8, B.C., Canada.

READER IN NUCLEAR ENGINEERING at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1.

RESEARCH ASSISTANT (preferably with a Ph.D. degree in chemistry or biochemistry, for work on the biochemical analysis of *Haemophilus pertussis* antigens—The Secretary, The Lister Institute of Preventive Medicine, Elstree, Hertfordshire.

RESEARCH ASSISTANT, to help with quantum mechanical calculations on tetrahedral and other nearly spherical molecules, using an electronic computer—Dr. R. A. Buckingham, University of London Computer Unit, 44 Gordon Square, London, W.C.1.

RESEARCH FELLOW (with experience in acoustic measuring techniques) **IN PHYSICS**, for work on materials for use in acoustic assemblies—The Registrar, The University, Leicester.

SENIOR SCIENTIFIC OFFICER/SCIENTIFIC OFFICER (honours graduate with a first- or good second-class honours degree), to undertake research on ceramic fuels for reactors, including the determination of physical and chemical properties over a wide range of temperatures, phase equilibria and investigation of fabrication techniques—The Group Recruitment Officer (1248/34), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Berks.

SENIOR RESEARCH OFFICER (PLANT PATHOLOGY) (with a good honours degree in botany (plant pathology) and suitable professional and administrative experience), to take charge of the Plant Pathology Division, Department of Agriculture, Kenya, and to guide and direct work of other pathologists in the Division—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/7/015.

SENIOR TECHNICIAN (capable of supervising setting-out of laboratories for physiological, biochemical and histological classes, and a knowledge of workshop techniques) **IN THE PHYSIOLOGY DEPARTMENT**—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

B.B.C. Engineering Monograph No. 20: The B.B.C.'s Mark II Mobile Studio and Control Room for the Sound Broadcasting Service. By L. E. H. O'Neill. Pp. 23. (London: British Broadcasting Corporation, 1958.) 5*s*. [189

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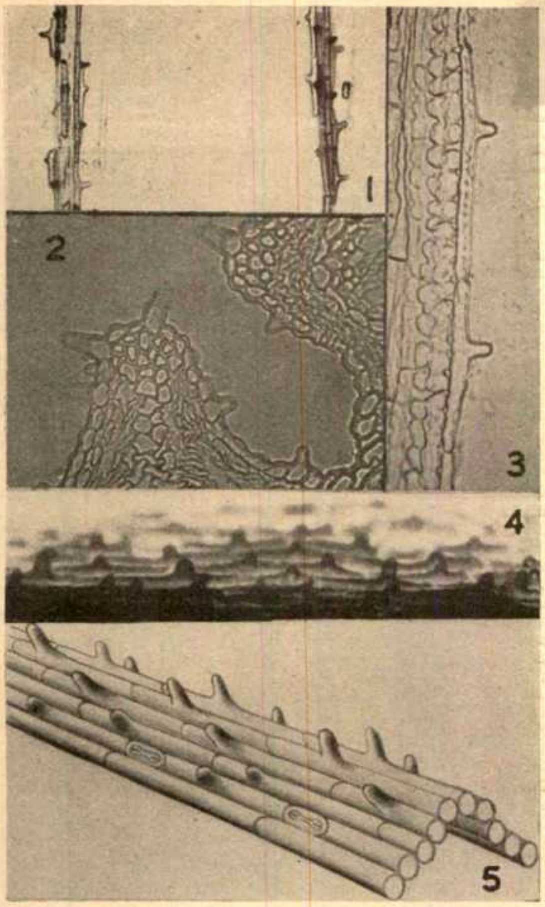

Fig. 1. *Nardus stricta*. Branched rods of opal in two ribs of the upper surface of the leaf (× 100). Fig. 2. Transverse section (× 270). Fig. 3. Longitudinal section (× 270). Fig. 4. Rows of branched cells in one rib, darkened by chromic acid treatment (× 220). Fig. 5. Diagrammatic representation of surface cells in one rib

The progressive silicification of *Nardus* leaves is being further investigated with material collected at intervals throughout the year. The special techniques used in this work have already been described[6].

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Sept. 3.

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Alary Polymorphism in the Gerroidea (Hemiptera Heteroptera)

The Gerroidea exhibit a marked alary polymorphism which has promoted many investigations since that of Poisson[1], who classified the various forms and attempted to investigate the genetics of this polymorphism by breeding experiments. This lead was followed by Ekblom[2] and Guthrie[3] without reference to Mitis[4], who had suggested a possible link between life-cycles and polymorphism. These breeding experiments have given varied and confusing results, and one may only conclude that any form can give rise to any other and that, as Guthrie[3] decided, the problem is not one of simple genetics.

In a recent study of the biology of *Gerris* and *Velia* species, I have been able to extend the observations made by Mitis[4], illustrating a close relation between life-cycle, habitat and polymorphism[5]. Only bivoltine species were seen to be polymorphic, the univoltine species being predominantly monomorphic. Of the univoltine species, *Gerris najas* (Deg.) and the *Velia* species are most commonly apterous and usually inhabit running water, whereas the monomorphic univoltine species inhabiting ponds and pools (*G. costai* (H.-S.), *G. gibbifer* Schum.) are mostly macropterous. In these instances it seems that the needs of distribution have determined the form of the single generation. Poisson[1] showed that short-winged forms were more abundant in the summer, and I have found that they are restricted to the summer generation in most cases. *G. argentatus* Schum., *G. odontogaster* (Zett.) and *G. thoracicus* Schum. exhibit an alternation between a macropterous overwintering generation and a polymorphic summer generation, while *G. paladum* appears to have an entirely short-winged summer generation. Two further species (*G. lacustris* (Linn.) and *G. lateralis* Schum.) resemble *G. odontogaster* but have in addition a small proportion (less than 10 per cent) of short-winged forms in the over-wintering generation.

All these species spend the winter months on land as adults, flying to and from over-wintering sites in the autumn and spring respectively. Having established themselves on suitable habitats these insects then resorb their wing-muscles and breed, producing in most instances a mixed generation of long- and short-winged forms. The species that do this occupy small ponds, pools and ditches or limited areas of lake-fringes. Since short-winged forms contain the same number of eggs as long-winged forms, and they both grow at the same speed[5], the usual theories of the significance of short-wingedness are no longer adequate. Instead I wish to stress the inability of short-winged forms to fly—an obvious but neglected point of view. It has been noted that long-winged forms lose their powers of flight after over-wintering and before breeding, as in many insects. The following generation consists of approximately equal numbers of flightless forms, which maintain the breeding population on the pond on which the species has already bred successfully, and alate forms which are capable of migration if the pond becomes either over-populated or a poor habitat (due to surface pollution, drought, etc.). In this context it should be recalled that *G. paludum* has an entirely short-winged summer generation, but inhabits the open water of lakes and large ponds and is not therefore exposed to the same selective pressures as described above. The alternation of a long-winged and a polymorphic or short-winged generation reflects the alternation of habitats occupied by the insects.

Ford[6] described three ways by which a balanced polymorphism such as this could be maintained: switching by simple genic segregation (as in *Sitona*[7]), selective predation alternately favouring one form and then the other, where both forms are produced in each generation (as in *Adalia*[8]), or by the switching of a gene complex by environmental factors. Mather[9] regarded the last method as the simplest system which could produce the situation in which types "successively vanish and reappear in a population", as I have observed to occur in these insects.

This approach to an old problem will be described in greater detail elsewhere, but it would seem that the results of previous breeding experiments must be largely discounted on the grounds that the offspring produced from any one form varies from one generation to the next, and most authors combine the results of breeding experiments made throughout the season. As the polymorphic form resulting from each breeding is probably influenced by the environment, the laboratory conditions should be carefully controlled. We are now in a position to select a species with a distinct 'alternation of generations' and attempt to operate the switch mechanism by such controlled breeding.

R. O. BRINKHURST

Department of Zoology,
University of Liverpool.
Aug. 29.

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Carbon Dioxide Fixation in Germinating Pine Pollen (*Pinus ponderosa*)

CARBON dioxide fixation by plant tissues other than those involved in photosynthesis has recently been reported for whole plant tissues and cellular particulates of roots[1,2]. This communication reports observations on the incorporation of carbon dioxide into the organic acid, amino-acid, and protein fractions of germinating pine pollen.

Pinus ponderosa pollen was germinated for 15 hr. at 29° C. in 0·01 *M* calcium–potassium phosphate buffer, *p*H 5·9, in the presence of the fungistat–bacteriostat mixture 'Mysteclin' (an antibiotic–antifungal mixture composed of tetracycline and mystatin; kindly supplied by the Medical Division, E. R. Squibb and Sons, New Brunswick, New Jersey). Radioactive potassium bicarbonate was added, and then the mixture was shaken for 1 hr. in a Warburg flask at 25° C. The reaction was stopped by acidification and the excess carbon dioxide removed by bubbling through inert carbon dioxide for 15 min. The mixture was then centrifuged and the supernatant removed from the pollen residue.

Table 1. PERCENTAGE OF CARBON-14 DIOXIDE INCORPORATED BY *Pinus ponderosa* POLLEN

Experiment	In supernatant		
	Total	Ether extract	Alcohol extract
1	24·6	11·2	2·1
2	34·1	13·1	3·4

Reaction mixture contained 200 mgm. pollen germinated 15 hr., 29° C.; 0·8 mgm. 'Mysteclin' in 0·002 *M* potassium phosphate buffer, *p*H 5·9. 0·5 μmoles potassium bicarbonate containing 125,000 counts/sec. was added after equilibration. The side-arm contained 0·5 ml. 2 *N* sulphuric acid added after 1 hr. incubation. Total volume, 2·5 ml.; temperature, 25° C.; incubation time, 1 hr.

Table 2. EFFECT OF PHOSPHOENOLPYRUVATE ON CARBON-14 DIOXID FIXATION BY GERMINATING POLLEN (*Pinus ponderosa*)

*p*H	Treatment	Percentage carbon-14 dioxide activity incorporated into	
		Supernatant	Residue
4·8	Heat inactivated	0·3	0·0
	Without phosphoenolpyruvate	9·0	0·6
	With phosphoenolpyruvate	10·7	0·5
7·4	Heat inactivated	0·3	0·0
	Without phosphoenolpyruvate	11·8	0·7
	With phosphoenolpyruvate	13·8	0·7

Reaction mixture the same as under Table 1 except 7 mgm. phosphoenolpyruvate was added where indicated; 90 μmoles phosphat buffer in each individual flask.

The total amount of radioactive carbon dioxide incorporated was determined by measuring the activity in aliquots of the supernatant and the residue. An ether extract and an alcohol extract of the reaction mixture were prepared. Activities in each of these fractions were ascertained by plating and counting in a windowless flow counter.

Table 1 indicates that most of the carbon-14 dioxide incorporated was in acid- or water-soluble components in the supernatant solution. After 1 hr. incubation, carbon-14 dioxide incorporated was higher in the organic acid fraction extractable in ether than in the alcohol-soluble components of the pollen supernatant.

Since many studies have indicated the presence of phosphoenolpyruvate carboxylase in plant tissues[3], the capacity of phosphoenolpyruvate to increase the incorporation of carbon dioxide by the pollen was investigated.

As Table 2 shows, carbon dioxide fixation increased when phosphoenolpyruvate was added to the incubating solution. About the same increase occurred whether the incubating medium was at the optimal *p*H of the phosphoenolpyruvate carboxylase or closer to the physiological *p*H. This agreement may be due to the high internal buffering capacity of the whole cell. The optimum *p*H for *P. ponderosa* pollen germination is 5·9, and germination is inhibited below *p*H 5·0 and above *p*H 7·0. This fact probably explains the total lower incorporation in the results shown in Table 2 as compared with those in Table 1. The stimulation due to phosphoenolpyruvate noted in particulate preparations[2] was much larger than that observed here. Since the inherent levels of phosphoenolpyruvate in pollen are quite high, perhaps alternate mechanisms of carbon dioxide fixation exist in germinating pollen or the treatment procedure used may not be optimal.

The pollen residues, which were insoluble in alcohol and ether, were hydrolysed overnight in 6 *N* hydrochloric acid at 117° C. Two-dimensional paper chromatograms were prepared of the alcohol extract of the hydrolysate using phenol/water and butanol/propionic acid/water as the solvents. The radioautographs showed activity in serine, aspartate, glutamate and malate. Radioautographs of the ether extract of the supernatant showed activity in malate, in what appeared to be citrate and in another organic acid.

The net synthesis of labelled amino-acids and possibly protein by germinating pollen, as evidenced by the hydrolysate studies, indicates that pollen on germinating into the female tissue not only absorbs water and activates inherent enzyme systems but probably can also synthesize the protein constitutive units of enzymes. Since pollen generally grows in a highly anaerobic environment, the capacity of pollen o incorporate carbon dioxide and synthesize amino-cids, proteins and possibly cell-wall materials may e an important growth mechanism in the plant eproductive cycle. The reduction and incorporation f carbon dioxide, coupled with the oxidation of arbohydrates present in the female gametophyte issue, may in part be the mechanism by which rapid ube elongation can occur in pollen grains with only ery limited carbon substrates.

This study was supported in part by grants from Resources For the Future, Inc., and the National Science Foundation.

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Young, L., and Graham, J. S. D., *Nature*, **181**, 1071 (1958).

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Effect of the Cotton Plant in the Sudan Gezira on Certain Leaf-feeding Insect Pests

COTTON in the Sudan Gezira, where some 240,000 feddans (1 feddan = 1·034 acres) of *Gossypium barbadense* L. are grown by gravity irrigation from the Sennar Dam, is attacked, particularly during the first 3½ months of its growth, by three important leaf-feeding insects, namely, the jassid, *Empoasca libyca* de Berg.; whitefly, *Bemisia tabaci* Gen. and thrips, *Hercothrips fumipennis* Bag. and Cam.[1]. These insects may cause important loss in yield of seed cotton[2], but their intensity of attack varies from season to season[2,3]. If, however, application of control measures is delayed until damage is easily visible, yield benefit from such control may be seriously reduced[2]. An object of entomological research is prediction of outbreaks of economic significance.

One cause of the seasonal variations in numbers was elucidated recently by a study of the effect of nitrogenous fertilizer on these pests. In an experiment in which 1 N. or 2 N. (where 1 N. is equivalent to 45 rotls of nitrogen; 1 rotl = 0·99 lb.) per feddan as ammonium nitrate was applied to cotton at different dates during the first 3½ months after sowing, it was found that the estimated Kjeldahl nitrogen in the dry matter of the foliage of plants receiving fertilizer was greater than in those not receiving fertilizer. Nevertheless, there was a tendency in all investigated treatments for the concentration of leaf nitrogen to fall as the season progressed, while infestations of jassids and whitefly increased with time. When, in an analysis of covariance, these latter effects were eliminated, a highly significant regression of jassid and whitefly densities on concentration of leaf nitrogen could be demonstrated. This finding is reminiscent of the work of Allen and Selmon[4] on *Phaedon coclearíae* F., and Le Roux[5] on *Tetranychus bimaculatus* Harvey, to quote two recent examples, and it is believed to be due to an increase in birth-rate with increased concentration of leaf nitrogen.

Table 1. MEAN NITROGEN CONCENTRATION IN COTTON LEAVES (PER CENT OF DRY WEIGHT) IN FIVE SAMPLES TAKEN BETWEEN EARLY SEPTEMBER AND LATE OCTOBER DURING FOURTEEN SEASONS

Locality	0 N. plots	3 N. plots	Mean
Hag Abdulla (south)	3·51	3·70	3·60
Gezira Research Farm (centre)	3·70	3·84	3·77
Turabi (north)	3·87	3·98	3·93
Mean	3·69	3·84	3·76

	Sites	Nitrogen
S.E.	+0·049	±0·059
Least sig. diff.		
($P = 0·05$)	0·14	0·17
($P = 0·01$)	0·18	0·22

Examination of results obtained by the Research Division on concentration of leaf nitrogen at three Gezira sites over fourteen seasons gave the means shown in Table 1.

The concentration of leaf nitrogen was affected by locality and fertilizer treatment. The effect on the two main Gezira cotton varieties, namely, *X1730A*, grown in the south, and Domain Sakel, grown in the north, was insignificant. There were also highly significant seasonal differences. Because of the established effect on Gezira cotton yields[6] of rains falling between July 1 and August 15 (pre-sowing rains) the covariance of concentration of leaf nitrogen on these rains was examined during the six seasons when all the cotton had been sprayed with DDT. The correlation coefficient of concentration of leaf nitrogen on pre-sowing rains was − 0·5842 which, for 22 degrees of freedom, is highly significant. There was evidence, however, that the effect was not direct, and seasonal variation in concentration of leaf nitrogen was caused by some uninvestigated factor itself correlated with rainfall.

The regression of the mean September and October concentration of nitrogen in the leaf material of the cotton plant on pre-sowing rains could be expressed by the equation:

$$X_2 = 4·07 - 0·0031X_1$$

where X_2 is the mean concentration of leaf nitrogen during September and October (as percentage of dry matter), and X_1 is the rainfall in mm. during July 1–August 15. The standard error of the regression coefficient is ± 0·0009).

The seasonal incidence of pests feeding on the leaves was recorded during four seasons at one site (Gezira Research Farm), and was found to be correlated with pre-sowing rains and the concentration of leaf nitrogen. The regression equation for rate of jassid increase is:

$$a = 18·03 - 0·071X_1\ (\pm 0·010)$$
$$a = 10·96X_2\ (\pm\ 0·69) - 35$$

where a is the mean rate of increase in jassid nymphs per 100 leaves per day

(other symbols as before, with standard errors of regression coefficients in brackets). This describes the rate of increase during September and October before spraying as well as that during October and November after DDT spraying.

The mean infestations during October and November, namely, after spraying, and at a time when the pests are considered to exert most effect on crop yields, were:

Jassids : $Y_1 = 156\cdot4X_2 - 478\ (\pm\ 20\cdot4)$

Whitefly : $Y_2 = 9\cdot71X_2 - 0\cdot27\ (\pm\ 0\cdot17)$

Thrips : $Y_3 = 4\cdot16X_2 - 0\cdot89\ (\pm\ 3\cdot17)$

where Y_1 is the mean number of nymphs of *E. libyca* per 100 leaves, Y_2 is the mean number of adults of *B. tabaci* (logarithm), and Y_3 is the percentage of leaves infested with larvæ of *Hercothrips* sp. (arc sin/percentage) (other symbols as before).

The regression coefficients for whitefly and jassid infestations were highly significant : that for thrips was not significant.

E. libyca is preyed upon by the Mymarid egg parasites *Anagrus* sp. and *Paranagrus* sp. while the *Aphelinid* parasites *Eretmocerus* sp. and *Prosaptella* sp. cause heavy mortality of the later instars of *B. tabaci*. All these parasites appear to be more numerous in seasons of good than of poor pre-sowing rains, but statistical evidence is deficient.

The results, although incomplete, raise the interesting possibility that the cotton plant in the Sudan Gezira may, by the seasonal changes in composition of its foliage expressed by percentage of Kjeldahl nitrogen, influence the rate of increase of some of its leaf-feeding insects in such way as to enable them to 'break away' from biological controlling agents. According to F. Crowther[7] the concentration of nitrogen in cotton leaves is determined by : (1) the concentration of nitrogen in the soil and (2) the rate of development of the plant. Jewitt[8] showed that the nitrate nitrogen in Gezira soils was negatively correlated with pre-sowing rains. The results so far available do not indicate that rains control leaf nitrogen directly, but determine it through other correlated factors influencing the early rate of development of the cotton plant.

It is hoped that this knowledge, considered in relation to some other aspects of the ecology of the pests concerned, will enable prediction to be made of pest outbreaks in the Sudan Gezira before the crop is sown. A full account of this approach in relation to the cotton jassid will be published elsewhere.

I am grateful to Sayed Ahmed Kordofani, of the Research Division, for access to his records of the growth and composition of the cotton plant in the Sudan Gezira, and to the Chief of Agricultural Research, Ministry of Agriculture, Sudan Republic, for permission to publish this work.

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[5] Le Roux, *Canad. J. Agric. Sci.*, **34** (1954).

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Bat Erosion as a Factor in Cave Formation

I have read with much interest the communication by W. A. King-Webster and J. S. Kenny[1] in which it is suggested that roosting bats can play a considerable part in cave excavation where the rock is soft. In particular, reference is made to the existence, in the roof of a limestone cave in Mt. Tamana (Trinidad), of bell-shaped cavities ranging in depth from 3 ft. to 6 ft., and in diameter at the mouth from 1½ ft. to 2½ ft., and which are used by sleeping bats. The suggestion is made that the habit of the bats of alighting at the lower edge of the bell and then jostling upwards into a central position, by continuation over innumerable years, has led to the excavation of these cavities, with maximum removal of rock at the mouth of the bell.

Ceiling cavities of the type described are, however, a commonplace feature in many limestone caverns, and indeed in portions of those caverns that have never been known to have been used by bats. This applies particularly to tunnels so far in linear distance from the cave entrance or in depth below it that they are beyond the normal zone of penetration of the bats. Such ceiling pockets, and also similar indentations in cave walls, have been described by Bretz in his classic paper[2], in which he elaborates on the theories, originally proposed by Davis[3], concerning the phreatic origin of certain types of cave tunnels and systems. Bretz specifically quotes such wall and ceiling pockets as examples of cave features of phreatic origin, pointing out that it is difficult to visualize their formation by any solution mechanism under conditions whereby there was an air space above the water surface. He therefore considers that such ceiling pockets were formed below the lowest normal water-table level (such as might occur at times of drought) and he directs attention to the fact that if the 'eating-out' process is continued long enough, adjacent pockets merge into one another, thus producing one of the effects described by King-Webster and Kenny.

During the course of the studies made by my wife and myself on the habits of certain cave-dwelling bats[4], in particular, the greater horseshoe bat (*Rhinolophus ferrumequinum*), we have often noticed ceiling pockets, of the type described above, in the natural caverns that exist in scattered outcrops of Devonian limestone, in the neighbourhood of Buckfastleigh in Devon. Some of these pockets are commonly used during the winter months by the greater horseshoe bats, probably because such dome-shaped cavities provide areas of roof that are free from draughts. It is, however, important to note that these caves were only revealed as a result of quarrying operations during the past century, and they were thus not occupied by bats until they were opened to the outside world, barely a hundred years ago. Although we have evidence in Devon that the claws of a greater horseshoe bat can mark the roof of a cave, at least to the extent of scratching off powdery surface deposits from the limestone, it would be surprising indeed if the colonies of bats could have excavated roof pockets to a depth of several feet in such a limited time. I therefore feel that although the 'bat erosion' effect postulated by King-Webster and Kenny may well occur with certain types of limestone, it represents at best only a secondary, and probably minor, contribution to the shape and size of the ceiling pockets described.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 24

Royal Geographical Society (at 1 Kensington Gore, London, W.7), at 5 p.m.—Lieutenant C. J. Wynne-Edwards, R.N.: "Hydro-aphic Survey in the Falkland Islands Antarctic Dependencies".

British Society for the History of Science (in the Council oom of the Science Museum, Exhibition Road, South Kensington, ondon, S.W.7), at 5.30 p.m.—Dr. G. J. Whitrow: "The Evolution Our Numerals and System of Numeration".

Institution of Electrical Engineers, Radio and Telecom-unication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—r. J. S. Seeley and Dr. J. Brown: "The Use of Dispersive Dielectrics a Beam-Scanning Prism"; Dr. J. S. Seeley: "The Quarter-Wave atching of Dispersive Materials"; Mr. A. Carne and Dr. J. Brown: Theory of Reflections from the Rodded-Type Artificial Dielectric".

University of London (in the Anatomy Theatre, University ollege, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. C. A. ogers: "Packing and Covering".* (Inaugural Lecture.)*

Royal Aeronautical Society (at the Institution of Civil Eng-eers, Great George Street, London, S.W.1), at 6 p.m.—Mr. J. E. ateman: "Inertia Guidance".

Tuesday, November 25

Institution of Chemical Engineers (at the Geological Society, urlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. H. E. ose: "A Suggested Equation Relating to the Mixing of Powders d its Application to the Study of the Performance of Certain Types f Machine".

University of London (at the London School of Hygiene and ropical Medicine, Keppel Street, Gower Street, London, W.C.1), 5.30 p.m.—Dr. E. H. Mercer: "Electron Microscopy and the ructure of the Living Cell".* (Eighth of eleven lectures on "The ientific Basis of Medicine" organized by the British Postgraduate edical Federation. Further lectures on November 27 and December and 4.)

Society of Instrument Technology, Data Processing Section t Manson House, Portland Place, London, W.1), at 6 p.m.—Mr. C. M. Barnes: "Digital Data-Recording for Nuclear Experiments".

Society for Analytical Chemistry, Physical Methods Group t the Chemical Society, Burlington House, Piccadilly, London, .1), at 6.30 p.m.—Fourteenth Annual General Meeting, followed y meeting on "Modern Methods of Purification".

Wednesday, November 26

University of London (at the Postgraduate Medical School of ondon, Ducane Road, London, W.12), at 2 p.m.—Dr. H. M. Sinclair: Essential Fatty Acids".*

Geological Society of London (at Burlington House, Piccadilly, ondon, W.1), at 5 p.m.—Mr. Graham F. Elliott: "Fossil Calcareous lgal Floras of the Middle East"; Miss Leonora A. Stevens: "The nterglacial of the Nar Valley, Norfolk" (paper communicated by r. R. G. West).

Royal Geographical Society (at 1 Kensington Gore, London, W.7), at 5 p.m.—Prof. Max Mallowan: "Excavations at Nimrud, 958".

Institute of Marine Engineers (at the Memorial Building, 6 Mark Lane, London, E.C.3), at 5.30 p.m.—Sir John Cockcroft, M., F.R.S.: "Recent Advances in Nuclear Engineering" (Sir harles Parsons Memorial Lecture).

Institution of Electrical Engineers, Supply Section (at avoy Place, London, W.C.2), at 5.30 p.m.—Dr. L. L. Alston and rof. F. M. Bruce: "Investigations of Power-Follow Current Phe-omena using a Synthetic Power Source"; Dr. L. L. Alston: "The mpulse Initiation of Arc Discharges".

British Institution of Radio Engineers (at the London School Hygiene and Tropical Medicine, Keppel Street, Gower Street, ondon, W.C.1), at 6 p.m.—Annual General Meeting. 7.15 p.m.—rof. E. E. Zepler: Presidential Address.

Society of Chemical Industry, Food Group (at 14 Belgrave quare, London, S.W.1), at 6.15 p.m.—Scientific Papers.

British Psychological Society, Medical Section (at the Royal ociety of Medicine, 1 Wimpole Street, London, W.1), at 8.30 p.m.—r. John Bowlby: "Studies of Parent–Infant Interaction in Man nd Animals—some Notes on Projects in Progress".

Thursday, November 27

Institute of Physics, Electron Microscopy Group (at the Royal ociety of Arts, John Adam Street, Adelphi, London, W.C.2), at 0 a.m.—Meeting on "Electron Staining".

University of London (at the London School of Hygiene and ropical Medicine, Keppel Street, Gower Street, London, W.C.1), at .30 p.m.—Mr. Michael Abercrombie: "Cell Surface and the Control Growth".* (Ninth of eleven lectures on "The Scientific Basis of edicine" organized by the British Postgraduate Medical Federation. urther lectures on December 2 and 4).

Friday, November 28

Institute of Physics, Electron Microscopy Group and X-Ray nalysis Group (at the Institution of Civil Engineers, Great George treet, London, S.W.1), at 10 a.m.—Joint Conference on "Precipita-on in Alloys".

Institute of Rural Life at Home and Overseas (at Friends International Centre, 32 Tavistock Square, London, W.C.1), at 1.15 p.m.—Mr. George Bredin: "The Impact of the Gezira Cotton-Growing Scheme on the Rural Population of the Blue Nile".*

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Turbidity Currents: High Speed Underwater Flow of Sediment Suspensions". Chairman: Dr. G. E. R. Deacon, F.R.S. Speakers will include Dr. A. S. Laughton, Dr. R. Stoneley and Dr. T. H. Ellison.

Physical Society (in the Large Lecture Theatre, Chemistry Department, Imperial College, Imperial Institute Road, London, S.W.7), at 5 p.m.—Prof. Niels Bohr, F.R.S.: "General Implications of the Atomic Nucleus" (9th (1958) Rutherford Lecture).*

Royal Anthropological Institute of Great Britain and Ireland (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. Sir Wilfrid Le Gros Clark, F.R.S.: "Bones of Contention" (Huxley Memorial Lecture).

Institution of Electrical Engineers, Medical Electronics Discussion Group (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion Meeting on "Problems Encountered in the Field of Neurophysiology".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. J. Z. Young, F.R.S.: "Squids, Cuttlefishes and Octopuses".

Friday, November 28—Thursday, December 4

Electronic Computer Exhibition (at Olympia, London, W.14).*

Monday, December 1—Wednesday, December 3

Business Computer Symposium.

Saturday, November 29

Institute of Physics, X-Ray Analysis Group (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 9.30 a.m.—Scientific Papers.

Botanical Society of the British Isles (in the Lecture Room of the Royal Horticultural Society, Vincent Square, London, S.W.1), at 12 noon—Exhibition Meeting.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer, Grade B (with a degree in electrical engineering or physics and preferably a special knowledge or industrial experience of some branch of the subject), in Telecommunications and Electronics—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (November 28).

Assistant Lecturer (with an honours degree in physics and preferably able to teach the subject to a high standard) in Physics—The Principal, Wigan and District Mining and Technical College, Wigan (December 1).

Lecturer or Assistant Lecturer (with a good honours degree and teaching experience) in Biology at the Royal Technical College of East Africa—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (December 5).

Lecturer (with special qualifications in botany or agricultural botany) in Botany—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (December 5).

Lecturer or Research Assistant in Bacteriology and Virology—The Registrar, The University, Sheffield (December 6).

Research Assistant (preferably with a Ph.D. degree and suitable experience in biochemistry and microbiology) in the Department of Bacteriology, to assist in a programme of work on the immunochemistry of *Bordetella pertussis*—The Registrar, The University, Manchester 13 (December 6).

Senior Lecturer and a Lecturer in Mathematics at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, December 12).

Lecturer (graduate in metallurgy or chemistry with special qualifications in the theory and principles of extraction metallurgy) in Metallurgy—The Registrar, The University, Manchester 13 (December 13).

Senior Lecturer/Lecturer in Chemistry at the University of New South Wales, Sydney, Australia—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (Australia, December 13).

Reader in Aeronautics at Imperial College, London, S.W.7—The Academic Registrar, University of London, Senate House, London, W.C.1 (December 15).

Senior Lecturer (registered pharmaceutical chemist) in Pharmacy at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 15).

Chair of Civil Engineering, Senior Lecturer or Lecturer in Mechanical Engineering, Lecturer in Engineering Mathematics, Lecturer in Civil Engineering, and a Lecturer in Electrical Engineering at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 29).

Chair of Botany—The Registrar, The University, Hull (December 31).

Research Fellow in the Physiology Department, Faculty of Rural Science, University of New England, Australia, to undertake research associated with a study of the comparative physiology of mammalian erythrocytes with particular reference to the physiological significance of individuality in the ruminant erythrocyte—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

LECTURERS OF ASSISTANT LECTURERS IN PHYSIOLOGY at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 31).

LECTURER OR ASSISTANT LECTURER (preferably with qualifications in mathematical analysis and/or statistics) **IN MATHEMATICS** at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 10).

LECTURER IN PURE MATHEMATICS—The Secretary, Queen's University, Belfast (January 15).

BROTHERTON CHAIR OF CHEMICAL ENGINEERING in the Houldsworth School of Applied Science—The Registrar, The University, Leeds 2 (January 31).

ENTOMOLOGIST (with a good honours degree in zoology and an interest in, and aptitude for, taxonomic work, and preferably experience in the Diptera particularly the Calyptrata) at the Commonwealth Institute of Entomology, London—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (January 31).

BIOCHEMIST (with a Ph.D. degree or equivalent research experience), for work on the metabolism of cell and organ cultures—The Secretary, Strangeways Research Laboratory, Wort's Causeway, Cambridge.

EXPERIMENTAL OFFICER (at least 26 years of age, preferably with a pass degree, or at least H.N.C. (engineering or applied physics) or equivalent), to carry out experiments designed to investigate the mechanical strength of complex assemblies, to instrument parts for experiments and to analyse experimental results—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. A.1895/34.

PHYSICAL CHEMIST, PHYSICIST OR METALLURGIST, for research on anodic oxide films—Dr. G. M. Shrum, Director, British Columbia Research Council, University of British Columbia, Vancouver 8, B.C., Canada.

READER IN NUCLEAR ENGINEERING at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1.

RESEARCH ASSISTANT (preferably with a Ph.D. degree in chemistry or biochemistry, for work on the biochemical analysis of *Haemophilus pertussis* antigens—The Secretary, The Lister Institute of Preventive Medicine, Elstree, Hertfordshire.

RESEARCH ASSISTANT, to help with quantum mechanical calculations on tetrahedral and other nearly spherical molecules, using an electronic computer—Dr. R. A. Buckingham, University of London Computer Unit, 44 Gordon Square, London, W.C.1.

RESEARCH FELLOW (with experience in acoustic measuring techniques) **IN PHYSICS**, for work on materials for use in acoustic assemblies—The Registrar, The University, Leicester.

SENIOR SCIENTIFIC OFFICER/SCIENTIFIC OFFICER (honours graduate with a first- or good second-class honours degree), to undertake research on ceramic fuels for reactors, including the determination of physical and chemical properties over a wide range of temperatures, phase equilibria and investigation of fabrication techniques—The Group Recruitment Officer (1248/34), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Berks.

SENIOR RESEARCH OFFICER (PLANT PATHOLOGY) (with a good honours degree in botany (plant pathology) and suitable professional and administrative experience), to take charge of the Plant Pathology Division, Department of Agriculture, Kenya, and to guide and direct work of other pathologists in the Division—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/7/015.

SENIOR TECHNICIAN (capable of supervising setting-out of laboratories for physiological, biochemical and histological classes, and a knowledge of workshop techniques) **IN THE PHYSIOLOGY DEPARTMENT**—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

B.B.C. Engineering Monograph No. 20: The B.B.C.'s Mark II Mobile Studio and Control Room for the Sound Broadcasting Service. By L. E. H. O'Neill. Pp. 23. (London: British Broadcasting Corporation, 1958.) 5*s*. [189

Higher Education in the United Kingdom: a Handbook for Students from Overseas. Revised edition. Pp. 208. (London: Longmans, Green and Co., Ltd., 1958. Published for the British Council and the Association of Universities of the British Commonwealth.) 5*s*. [189

Britain's Future and Technical Education. Pp. 12. (London: Ministry of Education, 1958.) [189

Fifth Report from the Select Committee on Estimates together with part of the Minutes of the Evidence taken before Sub-Committee B and Appendices, Session 1957–58; The Department of Scientific and Industrial Research. Pp. xvi+165. (London: H.M. Stationery Office, 1958.) 9*s*. net. [199f

Planning, Vol. 24, No. 426 (19 September, 1958): Problems o World Liquidity. Pp. 201–224. (London: Political and Economic Planning, 1958.) 2*s*. 6*d*. [229

The Future of Mineral Exploration. By Dr. Anton Gray. (Fourth Sir Julius Wernher Memorial Lecture.) Pp. 13. (London: Institution of Mining and Metallurgy, 1958.) [229

Ultra-High-Energy Nuclear Physics. By Prof. C. C. Butler. (Inaugural Lecture delivered 21 January 1958.) Pp. 26+7 plates. (London: Imperial College of Science and Technology, 1958. Distributed by the Modern Book Co., Ltd., 19 Praed Street, W.2.) 5*s*. [229

The Lichenologist, Vol. 1, Part 1. Pp. 48. (Cardiff: A. E. Wade, Secretary, British Lichen Society, c/o National Museum of Wales, 1958.) 20*s*. [229

Forum, Vol. 1, No. 1 (Autumn, 1958). (For the discussion of new trends in education.) Pp. 36. Annual subscription: 8*s*. 6*d*.; Single issues, 3*s*. (Leicester: P.S.W. (Educational) Publications, 1958.) [229

British Electrical and Allied Industries Research Associatic Technical Report L/T351: The Electrical Properties of Tungst Trioxide. By J. Hirsch. Pp. 10+2 figures. (Leatherhead: Briti Electrical and Allied Industries Research Association, 195 10*s*. 6*d*. [2

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TREASURY CONTROL AND SCIENTIFIC RESEARCH

IT has been apparent for some years, both from continued questions in the House of Commons and from the reports of the Select Committee on Estimates and the Committee of Public Accounts, that the House of Commons is increasingly concerned about the expenditure of the Department of Scientific and Industrial Research and of the University Grants Committee. The criticism advanced has not been unfriendly, for there has been no indication that Parliament wishes to restrict expenditure on scientific and industrial research; on the contrary, it is generally recognized that this should be expanded but that more care should be taken to ensure that full use is made of the results of such research. The Treasury has stoutly defended the autonomy of the universities and refused to agree to any proposals that appear likely to endanger their independence and freedom to determine the nature and balance of their work, and the reorganization of the Department of Scientific and Industrial Research, following the report of the Jephcott Committee, may be regarded as a sequel to some Parliamentary criticism of the Department.

Although the Treasury has made some concessions in regard to the expenditure of the Vote for the Department which give more freedom for the planning of research over a period of years, it would not appear that the problem of the control of expenditure on research, even in general terms, is fully understood by Parliament. A recent report from the Select Committee on Estimates (see *Nature*, October 25, p. 1111, and November 1, p. 1181), which was devoted to the work of the establishments of the Department, showed a concern with expenditure, particularly with the recovery of expenditure from those who had benefited by it, which could well prejudice the planning and support of the Department's programmes of research and even warp their direction. Furthermore, although the third report from the Committee of Public Accounts for the session 1957–58 fully exonerated the consulting engineers for the Jodrell Bank radio-telescope from failure to consult with the University professor in charge of the project, it is disturbing that the Committee should have advanced its criticism last session without inviting evidence from the University of Manchester or from the consulting engineer in charge of the building project. To say the least, the Committee of Public Accounts has shown little awareness of the dangers of waste and delay which may arise in such undertakings from the too rigorous application of financial accounting through estimates.

The latest report, while admitting that the previous report was ill-informed, gives no clue as to why and where the Committee regards the financial control exercised over the scheme as unsatisfactory. It welcomes the assurance that the remaining money required for the construction of the telescope will not be met, directly or indirectly, from public funds, but will be found from other sources by the University (see p. 1484 of this issue). There is no evidence that public money has not been properly and openly spent on the project, and equally no recognition of the difficulty of providing in advance firm estimates of cost for the construction of such novel equipment.

This is the most disturbing aspect of the report from the Committee of Public Accounts. It is vital that this affair should not deter other universities from entering on big building projects, or discourage the Department of Scientific and Industrial Research from its statutory duty of fostering fundamental research. Scientific research has come increasingly to depend on expensive equipment, the construction of which is often as much beyond the resources of individuals as it is beyond their capacity, without co-operation from others, to keep it fully and economically employed. As already noted, there appears to be a danger that the Estimates Committee may also divert the Department from the most fruitful discharge of its responsibilities.

Nor can we regard the danger as likely to be eliminated entirely if greater efforts are made in the matter of publication either through annual reports or in other ways. Attention to some comments of the Estimates Committee on this point should go some way to avoid unhelpful and misinformed criticism in Parliament, and might well provide the most effective solution to the real problem of public accountability. The reports of these two Parliamentary Committees demonstrate the urgency of this issue; but they equally show how imperfect and inadequate either the Committee of Public Accounts or the Select Committee on Estimates is as an instrument for the control of expenditure on such matters as research and development, though, as Basil Chubb showed clearly in his study of these Committees, that is not their function.

The whole question of Treasury control was examined by Prof. S. H. Beer in a thoughtful study published two years ago. He was not concerned with the practical aspect of its appropriateness to the needs of to-day, but, for the reasons just given, the more limited examination of Treasury control of expenditure in the sixth report from the Select Committee on Estimates for the session 1957–58[*] is of profound interest to the scientist and technologist at the present moment. Primarily the report is concerned with the methods of Treasury control employed and their effectiveness, rather than with actual expenditure, with the view of discovering whether they are such as to ensure economies in the Estimates, and attention is concentrated on control over supply expenditure, in contrast to establishment expenditure, which the Committee considers should be further examined. The latter relates to all expenditure on personnel remunerated from public funds, and since supply expenditure covers

[*] Sixth Report from the Select Committee on Estimates together with the Proceedings of the Committee, Session 1957–58: Treasury Control and Expenditure. Pp. 42. (London: H.M. Stationery Office, 1958.) 2*s*. net.

all other types of expenditure, it includes that on new projects such as the Jodrell Bank radio-telescope. This is nowhere discussed in the report; but for the scientist and technologist, one of the most important sections is that which discusses the way in which the Treasury exercises control by prior sanction of new projects and how it functions in practice.

First, it is important not only to scrutinize new policies but also to review carefully current policies. The Committee recognizes that it is uneconomical to cut a good new policy while a less-worthy policy is allowed to carry on without modification; but it found little to suggest that established policies are sufficiently reviewed and is disturbed at the absence of evidence of a constructive approach which would ensure that the reasons for continuing a policy or programme were independently and systematically sought. This is particularly important in regard to scientific and technological research, and it is in line with criticism from the Committee of Public Accounts and elsewhere that the Estimates Committee recommends that the Treasury should ensure that established policies in the civil field are more systematically reviewed.

It might well be asked whether this should be the function of the Advisory Council for Scientific Policy, or, in matters of defence research, of the Defence Research Policy Committee; and that could also apply to the second matter on which the Committee expresses concern. While it appreciates the difficulty of accurately estimating the cost of a novel policy or of research or development on a totally new type of weapon, and welcomes the appointment of a committee to consider and make recommendations about methods of managing and controlling research or development projects as likely to lead to more accurate estimating in this field, it rightly insists that sound decisions can only be taken on the basis of accurate estimates. The Committee suggests that supplementary estimates, due to the practice of under-estimating, can largely destroy effective budgetary control both of the national economy and of Government expenditure.

The third matter that caused the Estimates Committee some concern is the natural tendency, within the present annual system of Estimates and Accounts, to concentrate too much attention on the policy and expenditure proposals for the coming financial year, with too little regard to the commitments and consequences for future years. Such obsession can stultify forward planning, and it is the more serious in the context of the tendency to under-estimate the costs of policies and major projects. While the Ministry of Defence and the Treasury have recently introduced a practice of preparing—each summer—forecasts for three years ahead, on the basis of current policy, of the total and major features of defence expenditure, the Committee is disappointed that there seems to be little parallel effort on the civil side. Forecasts alone are not enough, though the defence forecast for the next year, when approved by the Government, becomes the defence budget on which that year's estimates are based; and the Committee urges that such a dynamic approach to expenditure should also be made in the civil sector.

In discussing next the way in which Treasury control operates over programmes of expenditur and annual estimates, the Estimates Committe appears to recognize fully that it is necessary fo certain purposes, such as university grants or the Department of Scientific and Industrial Research, to allocate expenditure for several years ahead, and i endorses the increased departmental responsibility which is involved in such a practice. It suggests however, that in some fields programmes might be made more specifically schedules of work to be done and that while the department is probably the bes judge of priorities, the need for capital works should be justified to the Treasury. Without making specific recommendations, it suggests that such specific programming might offer advantages in major research and development work where needs can be anticipated

A large part of the Committee's inquiry was devoted to hearing evidence about the merits of the control which the Treasury exercises by prior sanction of new projects, its effectiveness in achieving economies and the degree to which financial authority could be and has been delegated to spending departments. In view of the high proportion of Government expenditure which is now required for highly technical projects, the Estimates Committee rightly attaches great importance to these questions. Under the traditional system, such projects are not vetted by any technical officer except those responsible for initiating them, and it is obvious that the Estimates Committee has grave doubts as to the effectiveness of prior sanction control by the Treasury.

The Treasury does not employ professional or technical experts, and the value of such control depends accordingly largely on the skill with which the Treasury officer can criticize a proposal submitted by departmental officers who may have spent their entire working lives dealing with that subject, or a highly technical project submitted by a technical expert. Such lay critics are not necessarily ignorant—and the educational system could reduce the risk of them being so—and it may well be beneficial to require the expert to justify his claim for money to a man of general common sense and broad understanding. Nevertheless, the Treasury critic may wel feel inhibited in some circumstances, and be limited to judging whether a need is proved. The Committee found little indication that Treasury scrutiny made departments less meticulous than they should be in their own scrutiny, but it points out that this reliance on laymen encourages, and certainly makes possible attempts to blind the Treasury with science in relation to some types of project. It does not think that the method will work unless technical men play their part in discussions with the Treasury, and recommends accordingly that more attention should be paid to the advantages of associating technical officers with financial decisions. It is rightly observed that an awareness by technical officers of the financial implications of their proposals is an essential feature of a system which places a large measure of economic responsibility within spending departments.

The Estimates Committee does not, however, suggest the abandonment of control by prior sanction entirely, though it recommends some relaxation of its exercise, particularly when the expenditure is part of a specific policy decision approved by the Cabinet or Treasury or is a matter of detailed administration, or again when the raising of the financial ceiling will not remove a major field of departmental expenditure from Treasury control. It suggests that control could also be relaxed where greater use is made of the technique of control of expenditure by programmes as already indicated ; but it also points out that there are highly important and far from standard projects where inaccurate estimates are frequently made, and the Treasury has shown that its scrutiny can lead to economies, of which the Treasury is not seeing enough.

While on balance the present system appears to work reasonably well, and it is probable that much more expenditure is wasted through political decision or indecision than from the weaknesses which are noted by the Estimates Committee, on the evidence already discussed the Committee appears to be fully justified in its recommendation of a full inquiry into the theory and practice of Treasury control of expenditure. What is debatable is whether the small independent committee, with access to Cabinet papers, which it recommends will suffice, or whether the inquiry should not rather be entrusted to a Royal Commission. To the question whether the existing practice is as effective as modern conditions demand, it gives no definite answer, although it makes a number of suggestions for improving the system.

Some of these have already been noted, and others are made in considering the Treasury's interest in continuing expenditure, where the Committee again points out the danger that Supplementary Estimates or increases may divert attention from areas of expenditure which should be decreasing because of reduced demand, or because the costs of running an established service are lower than those of initiating it. While it recognizes that Supplementary Estimates are no longer regarded as discreditable, no positive proposals are made for dealing with this difficulty, which so far as the technical projects are concerned might well involve bringing technical experts into the Treasury, much as has been done in the Organization and Methods Division, and possibly developing a Division competent to say which new increases in departmental expenditure should be offset by new economies and which covered by Supplementary Estimates. Such a device might well have avoided the difficulty over the radio-telescope at Jodrell Bank, and need not involve serious delays.

For the rest, the Estimates Committee emphasizes the undesirability of leaving all initiative for economy to the departments, and the value of continuing Treasury interest. It is not satisfied, for example, that the Treasury takes sufficient interest in how grants-in-aid are spent or the services administered—apparently the attack on the University Grants Committee is only suspended. On research and development for defence purposes, it recognizes both the difficulty of control and the effect on the demand for skilled man-power and the critical resources of industry. The estimated expenditure for research and development by the Ministry of Supply alone this year exceeds £211 million, and it is vital to get the balance of effort right. With the pressure of demand on limited resources, it is not enough to examine new projects. Research and development programmes also require regular and careful combing to remove projects which have proved abortive and also those that have already produced most of the results that could be expected of them.

The crucial question is how such scrutiny and pruning are to be effected. Inevitably the Treasury relies chiefly on the scientific advisers to the departments, and the Chief Scientist of the Ministry of Supply said that the biggest and most effective action in reviewing research came from the pressure on scientific branches and establishments to do more and more tasks with limited funds and man-power. In consequence, they were always reviewing programmes and cutting out anything that did not seem to be sufficiently profitable. In other words, the pruning of projects is best undertaken by those responsible for the projects ; but their views may be too narrow, and accordingly reviews by the Defence Research Policy Committee or, in the civil field, the Advisory Council for Scientific Policy, are also desirable. The investigation now being made by Sir Claud Gibb's Committee may result in the Treasury becoming better equipped to judge the value of defence research and development work that has already been authorized ; but the Estimates Committee's report does not suggest that however effective Treasury control may become it will eliminate the need for such co-ordinating bodies.

The Estimates Committee's report indeed leaves grave doubts as to whether, in fact, either the Defence Research Policy Committee or the Advisory Council for Scientific Policy is functioning effectively. It is on bodies of this character that we must rely for the wide and expert views which can ensure that the scientific and technical effort of Britain is in balance, and that the demands on man-power and resources as well as on finance made by one sector are not out of proportion or impeding vital effort elsewhere. There, if anywhere, should be awareness that no country to-day can undertake every scientific or technological project at once. How this co-ordination is to be effected is a problem of the first magnitude to which urgent attention should be given. Some of the proposals of the Estimates Committee may help, but a fundamental condition of effective control will remain a real public understanding in Parliament, in the Government, in the Civil Service and among the general public of the nature and needs of scientific and technological work. To that a sound and effective publication policy could contribute, but the decisive factor in the end will be the development of an educational system adequate to the needs of a changing technological age.

ENCYCLOPÆDIA STATISTICA

The Advanced Theory of Statistics

By Prof. Maurice G. Kendall and Alan Stuart. Vol. 1 : Distribution Theory. (Three-volume edition.) Pp. xii+433. (London : Charles Griffin and Co., Ltd., 1958.) 84*s*.

FIFTEEN years ago, Prof. M. G. Kendall published the first of two volumes that rapidly established themselves as indispensable to statisticians. Even critics who disagreed with some of the controversial views expressed and found flaws in points of detail not only were bound to admire Kendall's versatility in his comprehensive coverage of mathematical statistics but also came to accept the books as standard works of reference. These fifteen years have seen consolidation in some fields, reduction of emphasis in others, new lines of theory, and above all new understanding of the inter-relations between parts of the subject. In the preparation of a completely revised and re-set edition, Prof. Kendall has had Mr. A. Stuart as collaborator. This edition is to appear in three volumes ; the magnitude of the task can be appreciated from the fact that Vol. 2, "Statistical Inference and Statistical Relationship", is planned for publication in 1960, and for Vol. 3, "Statistical Planning and Analysis, and Time Series", no date has yet been given.

Evaluation of one volume alone is unsatisfactory, because the balance of the whole work cannot be judged. The first twelve chapters are essentially the same as the first eleven chapters in the previous Vol. 1, but have many sections improved in rigour or brought up to date. Frequency-generating functions, a surprising omission previously, are now employed to good advantage. Changes of emphasis on systems of distributions are typified by the virtual omission of the Charlier type-*B* series and the inclusion instead of a good summary of the lognormal distribution and Johnson's transformations. The presentation of the calculus of probabilities is now much clearer ; statement of the weak and strong laws of large numbers is one aspect of its improved coherence, yet the authors' practical contention that "In statistics it is a mark of immaturity to argue overmuch about the fundamentals of probability theory" is well maintained. In many places, as in the discussion of distributions of ratios of statistics, groups of related topics are better integrated than before. The long account of *k*-statistics and symmetric functions, inevitably somewhat tedious reading to those who lack special interest in it, is none the less an excellent account of a subject to which Kendall has himself made outstanding contributions ; formulae appropriate to finite populations are now included, and the new Chapter 13 develops generalizations to bivariate distributions.

Since publication of the first edition, one major growth of statistical theory has been in connexion with order statistics and non-parametric analysis. The ultimate importance of this work to statistical thought cannot yet be assessed, but an excellent survey of its main themes rightly appears as a new chapter. A good account of multivariate normal theory from a modern point of view forms Chapter 15, and a final chapter summarizes the derivation and properties of the main distributions associated with the normal.

Although courses of instruction in statistical theory can well be based upon this book, as an aid to which more than 300 exercises (mostly fairly difficult) are included, a majority of statisticians will probably value it and its successors chiefly as an encyclopædia. Not only are the main lines of development of theory clearly presented, but also the authors embroider their account with mention of many topics of lesser importance ; to have these recognized and made more accessible than in past volumes of journals adds greatly to the interest and value of "Kendall and Stuart" as a work of reference. Indeed, my own regret is that space has not been found for a still greater range of minor themes : references to books and papers listed in previous editions but now excluded as falling outside the stream of current statistical thought could still have been justified for encyclopædic purposes. One fault, perhaps inevitable in an encyclopædia, is the emphasis on facts and the comparative neglect of discussion of the circumstances in which these facts are useful. The sections on χ^2, for example, are still somewhat perfunctory, and no reader would guess from them that the uses of this statistic in the analysis of observational records are so diverse.

Prof. Kendall has placed all statisticians in his debt for the breadth of his publications during the past fifteen years ; the next two volumes in this series will be awaited with interest and with the hope that all will continue to be so conscientiously revised as statistical theory continues to grow. D. J. Finney

THE SCATTERING OF LIGHT BY SMALL PARTICLES

Light Scattering by Small Particles

By H. C. van de Hulst. (Structure of Matter Series.) Pp. xiii+470. (New York : John Wiley and Sons, Inc. ; London : Chapman and Hall, Ltd., 1957.) 96*s*. net.

THE problem of the scattering of electromagnetic radiation by a homogeneous sphere, to which partial solutions in particular cases were provided by Rayleigh and others towards the end of last century, was finally solved by Mie in 1908. The application of the formal Mie solution presents great difficulties. The series in which it is expressed may converge slowly, and the investigator who seeks to apply the formula to a particular problem is therefore fortunate if he finds ready-made tables or curves for the scatter functions relevant to the refractive index and ranges of the ratio of radius to wave-length with which he is concerned.

It was in 1945, while Dr. H. C. van de Hulst was investigating the effects of interstellar dust, that he became aware of these difficulties and was led first to undertake a thorough review of the literature and then to make important contributions himself, both to the theory and to filling the gaps by new computations. In this valuable book, he has assembled in an admirably clear and logical manner the results of his work of reviewing, and of his own further independent studies of, this very complex subject.

Van de Hulst confines himself to the theory of 'independent scattering', that is, to the scattering by particles sufficiently distant from each other that "for all practical purposes, the intensity scattered by the various particles must be added without regard to phase". It appears that separation by a distance as small as three times the radius yields independent scattering; actually, in a dense fog, the mutual separation is of the order of twenty times the radius of the droplets. He imposes the further limitation that 'single scattering' alone is considered, the criterion for this (that is, for the absence of 'multiple scattering') being that doubling the concentration of particles in a sample doubles the scattered intensity.

The first of the three parts into which the book is divided is concerned with the development of general theorems for scattering by particles of arbitrary size, shape and composition.

The second part provides the theory necessary for the calculation of the scattering for a wide variety of special particles large and small compared with the wave-length, absorbing and non-absorbing, and of various shapes. This is by far the largest and most important part of the work and is the section that is certain to be widely consulted by applied scientists seeking aid with numerical calculations. Nearly every chapter contains new formulæ and numerical results, and a valuable bibliography of numerical computations by the Mie theory is provided. There is an excellent chapter on the optics of a raindrop which includes a penetratingly critical review of theories of the rainbow and a full account of the theory of the glory, extended in a later chapter by a brief examination of the effect of the existence of surface waves.

The final part of the book consists of four short chapters on the practical application of the theory to the explanation of scattering phenomena in the domains of chemistry, meteorology and astronomy, and on the use of scattering and extinction measurements to derive estimates with varying accuracy of refractive index, size and distribution of sizes, shape and orientation, and chemical composition of the particles.

A valuable feature of this outstanding book, which should be the standard work for many years, is the comprehensive list of carefully annotated references at the end of each chapter. JAMES PATON

COMPLEXOMETRIC ANALYSIS

The Analytical Uses of Ethylenediamine Tetraacetic Acid

By Prof. Frank J. Welcher. Pp. xvii+366. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 64*s*.

AN important development in chemical analysis during recent years has been the application of aminopolycarboxylic acids, especially ethylenediamine tetraacetic acid, as complexing agents. Many publications concerning the analytical uses of this acid have appeared, and Prof. Welcher's book provides a summary of information gleaned from the 963 bibliographical references listed at the end.

The author states that he has endeavoured to collect information from all papers describing the use of ethylenediamine tetraacetic acid in inorganic analysis, but that critical evaluation of each method has not been attempted and that the book is not intended as a manual of recommended methods, though details of many procedures are given with reports on interference, optimum conditions, and claims as to accuracy.

The book opens with a discussion of general principles, including complex-formation constants, titration methods, colorimetric determinations, and the effect of *p*H on complex-formation. Succeeding chapters provide much information concerning end point detection, metal indicators, the use of masking agents, the determination of more than thirty metals, indirect methods for anions, and applications to polarography, amperometry, and qualitative analysis. Two chapters are devoted to the determination of calcium and magnesium in water and in a great variety of materials ranging from alloys, cements, and rocks to biological fluids and foods.

The subject-matter is mainly concerned with volumetric applications of ethylenediamine tetraacetic acid, but an interesting final chapter concerns the uses of the reagent to complex interfering ions, and thus facilitate more orthodox analytical work such as the colorimetric determination of bismuth, cobalt, and copper with diethyldithiocarbamate, the determination of mercury with dithizone, the spectrophotometric determination of beryllium in the presence of aluminium, the mannitol–boric acid titration in the presence of iron and other metals, the separation of the rare earths, and the gravimetric determination of uranium in the presence of other metals.

This book will be a very useful guide for the analytical chemist, though, as the treatment is mainly non-critical, many of the methods dealt with will call for some preliminary trials before being accepted for any specific purpose. However, this is in no way a criticism of Prof. Welcher's comprehensive compendium, which will be of the utmost assistance to those interested in the analytical chemistry of ethylenediamine tetraacetic acid. C. O. HARVEY

NOISE

Principles of Noise

By Dr. J. J. Freeman. Pp. x+299. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 74*s*. net.

DURING the past few years considerable attention has been focused on the problem of detecting ever smaller signals; this requirement has been forced upon us from a number of quarters, prominent among which are radio, astronomy, and electromedicine.

The detection of these small signals is accompanied by the desire for a theory applicable to the random fluctuations with which the signal may be associated. Although investigations into electrical noise date back to Johnson's classical paper in 1928, until recently there have been very few books written in an attempt to integrate knowledge throughout the whole field of noise, and even fewer which have approached it in a tutorial manner designed for a reader with little previous knowledge of the subject. This is the task which the author has set himself.

The preamble to his book consists of two chapters dealing with the fundamental mathematical tools with which to attack noise problems. Starting from the basic notion of Fourier series he leads in a simple manner to the idea of Fourier integral and transform. He also introduces the concept of power spectrum and its relationship to autocorrelation function. The chapter on probability covers the principles of this subject, giving insight into the idea of variate space and leading from the notion of discrete probabilities to that of a continuous probability density.

The main text starts with a definition of random processes. Mention is made of the properties of stationary and ergodic processes, illustrating them by means of suitable examples. In fact, one of the great virtues of the book from the point of view of the student approaching the subject in complete ignorance is the large number and relevance of the illustrative examples.

These principles are applied to the derivation of a number of fundamental circuit aspects of noise; derivations which, perhaps in an over-zealous attempt to be straightforward, become rather laboured. The application to practical electrical devices gives a good insight into the noise behaviour of a number of physical devices, in the process of illustrating the application of the theory. This section is naturally far from exhaustive, and this point might have been better brought out if a wider variety of physical systems had been considered; the only devices mentioned are thermionic valves; no mention is made of noise in transistors or other solid-state devices. The section dealing with measurement of noise is, unfortunately, far too brief to do justice to the topic, but as this is essentially a theoretical book this is not of major importance.

The book develops with further theorems related to noise figures and the calculation of optimum arrangements for minimizing them. The reason for this is fully explained in the following chapter which, in great detail, enunciates the problem of detecting ever smaller signals in the presence of noise, stressing the close connexion between accuracy and time taken for an observation.

The remaining section of the book deals with the theoretical aspects of the characteristic function, leading to an analysis of the detection of alternating signals in the presence of noise by means of a non-linear detecting element.

The reason for the final chapter in the book, dealing with target noise, is seen in the author's personal interest in this field. As a consequence, its irrelevant inclusion in a book dealing primarily with the fundamental theory of noise may be excused.

The book thus well comes up to the author's aim of providing a simple introduction to the techniques of noise calculation. From this point of view it is probably the best book yet available for the student and yet one which will be valuable for reference at a later date.

R. A. King

CONVEX GEOMETRY

Convexity

By Dr. H. G. Eggleston. (Cambridge Tracts in Mathematics and Mathematical Physics.) Pp. viii + 136. (Cambridge: At the University Press, 1958.) 21*s*. net.

Problems in Euclidean Space

Application of Convexity. By Dr. H. G. Eggleston. (The Adams Prize Essay of the University of Cambridge, 1955–6.) (International Series of Monographs on Pure and Applied Mathematics, Vol. 5.) Pp. viii + 165. (London and New York: Pergamon Press, 1957.) 40*s*. net.

THE basic concept of convexity is simple but powerful. For example, given an ordinary function the graph of which is convex, so that any arc is below its chord, if arbitrary positive masses are attached to a finite number of points, the centroid of such masses is obviously above the curve; but this almost trivial observation can be made to yield most of the significant elementary inequalities of analysis, such as the Cauchy–Hölder inequality. Again, a set of points is convex if, when A and B belong to the set, so do all the points of the straight line segment AB. Since many elementary geometrical figures are convex, the question of the relation of convexity to properties of such figures at once arises, leading, for example, to the curious and important notion of curves of constant width.

Dr. H. G. Eggleston's two books are complementary. In the Cambridge Tract, the object is to develop the general theory of convexity, for its own sake, in n-dimensional Euclidean space; in the Pergamon Press volume, which consists of the Adams Prize Essay in the University of Cambridge for 1955–56, convexity is the thread connecting a variety of geometrical problems in Euclidean space of two or three dimensions.

A natural description of a plane convex set would be that it lies wholly on one side of any tangent to its boundary, but this is too restrictive (it would rule out a triangle); more generally and more precisely, through every point on the boundary of a convex set there passes a line which does not intersect the set. This provides a convenient and powerful alternative definition of convexity, once its equivalence to the earlier definition is established. Two other valuable tools are the relation between convex sets and convex functions, and Blaschke's selection theorem, which asserts that an infinite aggregate of closed convex sets in a bounded space must contain a sequence converging to a limit set which is closed, convex and not vacuous. All this basic theory is developed for n-space in the first four chapters of the Cambridge Tract. The fifth chapter concerns Minkowski's definition of surface area (the volume is simply the appropriate Lebesgue measure); this is a somewhat difficult chapter, for the motivation will scarcely be clear to the general reader. The final two chapters deal with typical geometrical problems: isoperimetrical properties and curves of constant width.

The second book is divided into four sections. In the first, convexity is merely a tool for the investigation of results in point-set theory; in the second, Borsuk's conjecture that any set of diameter d in n-space is the union (sum) of $n + 1$ sets each of diameter less than d is proved for 3-space by reducing the problem to one concerning convex sets. The third section deals with problems in which convexity appears as a natural restriction on the class of sets involved, such as the measure of closeness of approximation to a convex set by a convex polygon. Finally, special problems about plane convex sets are considered: sets of constant width, and inequalities connecting a plane convex set and its circumscribing triangles.

Dr. Eggleston's exposition is patient and thorough. But the book is for the specialist rather than for the general mathematical reader. Proofs are inevitably long, because of much complicated detail and some tedious but necessary enumeration of cases. Even the author's craftsmanship cannot always cut clearly through the tangle of detail. But there are many unsolved problems in this field, and the young research worker who has a taste for this type of patient analysis will find Dr. Eggleston's books invaluable, both as an account of the present state of knowledge and as a guide to likely lines of advance.

T. A. A. Broadbent

RADIOACTIVITY DUE TO FISSION PRODUCTS IN BIOLOGICAL MATERIAL

By Prof. W. V. MAYNEORD, W. ANDERSON, R. E. BENTLEY, L. K. BURTON, J. O. CROOKALL and N. G. TROTT

Physics Department, Institute of Cancer Research : Royal Cancer Hospital, London

THE release of artificial radioactive products into the biosphere has raised the problem of determ-ing whether or not the resulting increase in the adioactivity of the environment represents a poten-ial hazard to human beings. In attempting to assess ny possible hazard, the first necessity is to obtain ccurate, detailed information on the nature and mounts of radionuclides, both natural and artificial, ccurring in the environment and the human body. ifficult problems arise in these studies of artificial adionuclides, and elaborate techniques are needed r distinguishing them from naturally occurring adioactive species. In Great Britain admirable vestigations have been made by the United King-om Atomic Energy Authority[1–3]. However, in rder to obtain independent information we have ndertaken studies of beta- and gamma-emitting ssion-product radionuclides in biological materials Table 1), the programme being linked with other vestigations in this Department on natural alpha-mitters[5,6]. We outline below the methods we are sing and our initial results for a series of samples of ows' milk and human milk. By a fortunate coincidence the most detailed part of our cows' milk ampling programme covered the week in which the ccident occurred at the Windscale No. 1 pile, and he results therefore provide an interesting record of he levels of fission products in milk produced at that me in Cardiganshire, Wales.

Estimation by Chemical Separation and Beta-Counting

Several radionuclides may be present in a single iological sample, and the levels of artificial and aturally occurring radioactivity in the sample may e of the same order of magnitude. For this reason, nd to concentrate the activity, a suitable chemical eparation must be made before the sample is assayed by beta-counting. Identification of particular radionuclides should be supported by measurements of half-life, or of maximum beta-energy.

able 1. RECENT DATA (REF. 4) FOR CERTAIN FISSION PRODUCTS

Nuclide	Half-life	Chief transitions			Remarks
		Beta	Gamma		
		Max. energy (MeV.)	Energy (MeV.)	Quanta emitted per 100 disintegrations	
Sr-89	54 days	1·46*	—	No gamma	–
Sr-90	28 years	0·61*	—	No gamma	—
Y-90	65 hours	2·24*	—	No gamma	Product of Sr-90
I-131	8·05 days	0·61	0·364 0·638	83 7·5	—
Cs-137	30 years	0·52	—	No gamma	—
Ba-137*m*	2·60 min.	No beta	0·662*	82†	Product of Cs-137

* Sole transition.
† For 100 disintegrations of cæsium-137.

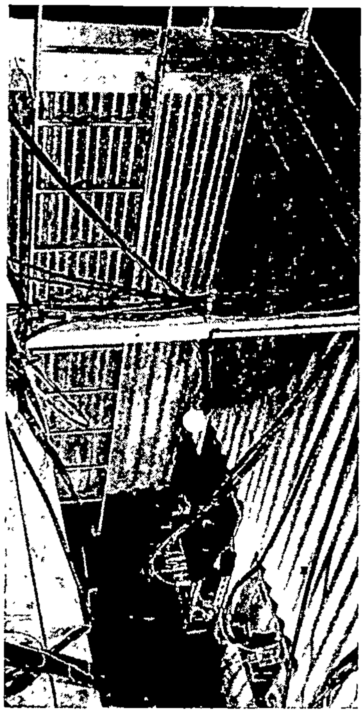

Fig. 1. Low-background pit for sample counting

The activities to be measured are, of course, frequently very small. Preliminary investigations showed that a beta-counting system, with a background of between 0·1 and 1·0 c.p.m. (counts per minute) and an efficiency of approximately 20 per cent, would be suitable for measurements on a wide range of samples. Assemblies were therefore constructed using end-window Geiger–Müller counters (G.E.C. Type *GM*4 *LB*), which have low natural backgrounds. The cosmic-ray background was reduced by the use of an anti-coincidence shield, incorporating 20 glass-wall cosmic-ray counters (20th Century Electronics, Type *G*24). To shield the whole assembly from external gamma-radiation, use was made of the chalk which forms the top rock stratum of our laboratory site, and is low in radioactive content. A pit 8 ft. × 3 ft. × 7 ft. deep, with five short galleries (Fig. 1), was excavated in the rock beneath a basement laboratory. The counter assemblies were set up in these galleries with additional shielding of 2 in. of 50-year-old lead. The background so obtained for a number of sample

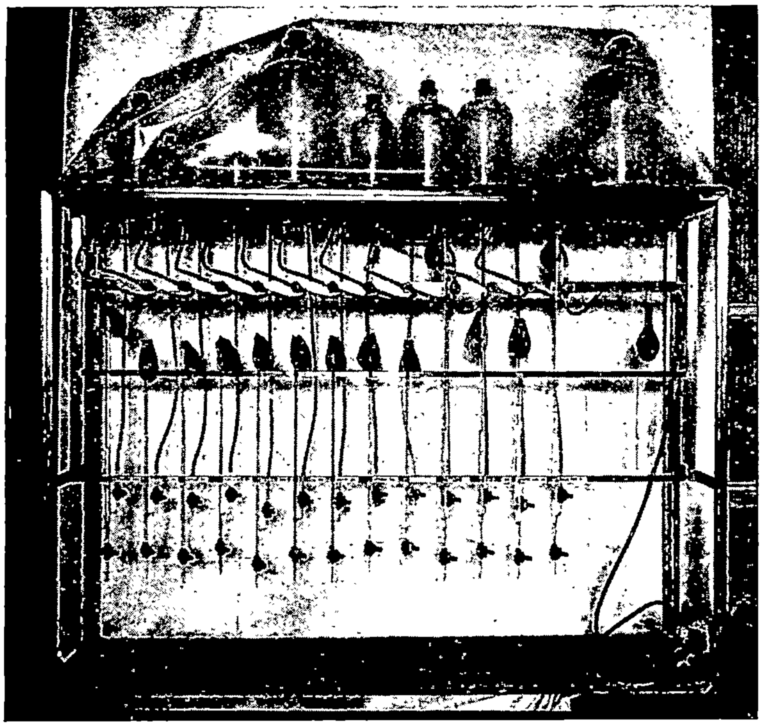

Fig. 2. Dispensing system for isolating chemical reagents from the laboratory atmosphere

counters has ranged from 0·4 to 0·6 c.p.m., individual counters showing variations from the mean not exceeding ± 0·05 c.p.m. over a period of several weeks.

The analysis of samples for radiostrontium involves the use of a number of chemical reagents and separation procedures. To reduce the possibility of obtaining false results due to radioactive contamination, several precautions were taken. Adequate stocks of prepared reagents, isolated from the atmosphere, were stored in a special dispensing system (Fig. 2). Provided that a control sample showed no measurable activity, it could be assumed that none would be introduced by the reagents during the ensuing series of estimations. The laboratories were quite separate from those used for normal radioactive tracer work, and access was strictly limited. We have collected a number of sealed samples of pre-1945 materials, including some of the foodstuffs recently recovered from the Scott/Shackleton stores in Antarctica. These fission-product-free materials have been used in periodic control runs, which have shown the reagents to be free from radioactive contamination at levels we can detect.

The radiochemical procedures used in the estimation of strontium-90 and strontium-89 were basically those described by Bryant *et al.*[7]. Milligram quantities of inactive strontium are added as carrier to ashed samples of biological materials, followed by chemical separation of the strontium from the mixture. Final scavenging with barium chromate and then ferric hydroxide removes trace amounts of natural series radionuclides and rare earth fission products that may be present. A small amount of inactive yttrium as carrier is then added to the strontium fraction and the solution stored for about two weeks while yttrium-90 builds up to nearly complete radioactive equilibrium with the parent strontium-90. Estimations of strontium-90 are based on measurements of the daughter yttrium-90 selectively precipitated as yttrium hydroxide and mounted for counting as oxalate. Estimations of strontium-89 are based on measurements of the strontium fraction precipitated as carbonate allowance being made for strontium-90 and yttrium-90 in the precipitate.

The decay of yttrium-90 and strontium-89 fractions has always been followed. Typical results are shown in Fig. 3. In our experience measured half-lives agreed, within the limits set by counting errors with the known values for these nuclides.

The end-window counters were calibrated individually for each of the nuclides studied. The stock solutions had been standardized in this laboratory (for strontium-90 plus yttrium-90 also at the National Physical Laboratory), by 4π beta-counting[8]. Dilutions, prepared gravimetrically, were treated chemically as described above to prepare sources of known activity for counting. As a further check on the accuracy of the calibrations, measurements were made on an international strontium-90 plus yttrium-90 milk ash standard, distributed by the United States Atomic Energy Commission Health and Safety Laboratory our values were in good agreement with the mean of those of several other laboratories.

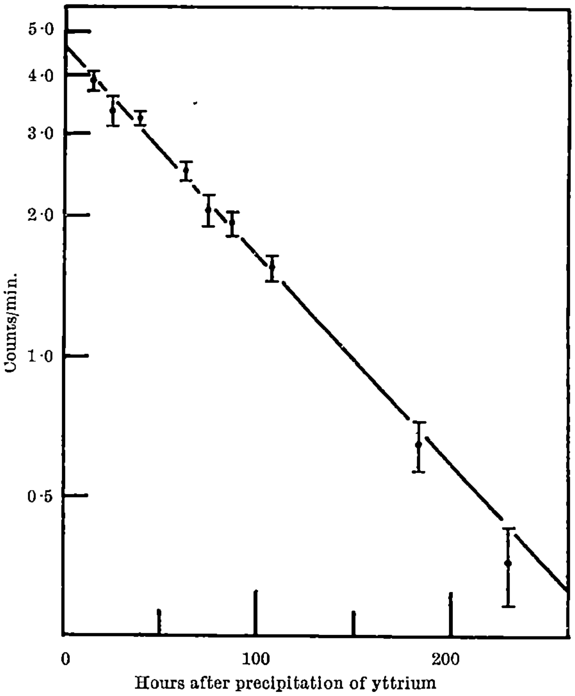

Fig. 3. Typical decay curve for yttrium-90 sample derived from cows' milk (sample *CMF* 1). The errors shown (2 σ) are based on the total number of counts measured for each point corrected for background. The curve is fitted by the method of least squares with due allowance for the weight of each measured value. Measured $T_{1/2}$ = 66·4 hr. (σ = 0·7). (cf. 65 hr., ref. 4)

Estimation by Gamma-Scintillation Spectrometry

In favourable cases gamma-emitting nuclides in biological samples may be identified and assayed by direct measurements using a sodium iodide gamma-scintillation spectrometer. This technique has the further advantage that comparatively large samples may be used, since self-absorption of gamma-radiation is small.

We have used two systems, each of which was carefully calibrated with standard sources prepared in a form simulating the samples to be assayed. In the first system a crystal 4 in. diameter × 2 in. high and photomultiplier, coupled through standard equipment to a single-channel pulse-height analyser, was set up in a gallery of the low background pit. A second, and improved system, was designed to have an inherent low background and high stability. A crystal 3 in. diameter × 3 in. high, with very low natural radioactive content (2–4 parts per million potassium), canned in electrolytic copper and having a quartz window, was used (Harshaw Chemical Co.). The associated photomultiplier has a stainless steel housing, and the whole detector is shielded by 16 in. of steel. The system is operated in conjunction with a 99-channel pulse-height analyser (A.E.R.E. Type 1438*B* and *C*) and has a total background above 100 keV. of 350 c.p.m. The capabilities of our equipment are illustrated by the ability to identify and measure as little as 20 μμc. of cæsium-137 in a human milk sample in measurements over a counting time of 36 hr.

Measurements on Cows' Milk

At the present time, the immediate sources carrying fission products into the human body are not fully known. It is clear, however, that in Great Britain milk is a principal source of strontium-90, the fission product causing greatest concern[9]. We therefore decided to make measurements of strontium-90 in milk in order to establish the average level for a well-defined area and to follow the general trend of levels with time.

Apart from the influence of fall-out rate, variations in the levels of fission products occurring in milk may be caused by numerous factors. For the proposed investigation, it was essential to obtain samples representative of a large quantity of milk so that fluctuations, reflecting special conditions at individual farms, would be smoothed out. By kind co-operation of the Milk Marketing Board we have arranged for a supply of spray-dried, skimmed-milk samples to be sent to us at weekly intervals from Felinfach Creamery, where up to 30,000 gallons of milk, drawn from more than 1,500 farms, are processed daily. The farms are located in an area of mixed coastal and upland herbage covering a few hundred square miles in west Cardiganshire. Each sample is a composite one, prepared from periodic samplings of the dried product made at half-hourly intervals throughout a given day. Four consecutive weekly samples are eventually bulked together, and it is proposed to measure the levels of strontium-90 in these bulked preparations over an extended period. In addition, the levels of other fission products, particularly strontium-89 and cæsium-137, are being followed.

As a preliminary investigation, in order to obtain information on the variations which might occur over short times, a series of daily samples was obtained covering October 5–13, 1957. During this period radioactive material was released into the atmosphere as a result of the accident at the Windscale No. 1 pile (October 10 and 11)[10]. Numerous measurements were made on the levels of activity in these daily samples and afterwards in samples produced at fortnightly intervals until December 1957, when the bulked series was commenced. The results of these measurements are shown in Fig. 4. In addition to the results shown in Fig. 4, measurements were made on three samples produced at the same creamery during 1956–57 (Table 2,*a*). The principal effects of the Windscale accident, discussed below, were temporary increases in the iodine-131 and cæsium-137 levels; no effect on the radiostrontium-levels was detected. The main features of the results for each nuclide studied are as follows:

Strontium-90. The main information on the levels of strontium-90 occurring in milk produced in Great Britain is that published by Bryant *et al.*[1,2]. The annual mean values found by these workers for a series of samples produced in Somerset during 1955 and 1956 were respectively 4·0 and 4·5 S.U. (1 S.U. = 1 μμc. ^{90}Sr/gm. calcium). Recently, they have reported a value of 5·1 S.U. (median) for 1957 for the same series[11]. Further measurements on samples produced during October and December 1956 at five other locations in Britain gave values ranging from 3·9 to 10·3 S.U., indicating a regional variation. Such variations have been discussed recently in terms of climatic and soil conditions[12].

The results obtained by us for Cardiganshire during 1956–57 are in close agreement with those of Bryant *et al.* for the same region and period (Table 2,*a*). Our later results, extending from October 1957 to May 1958 (mean value = 8·3 S.U.), show little change

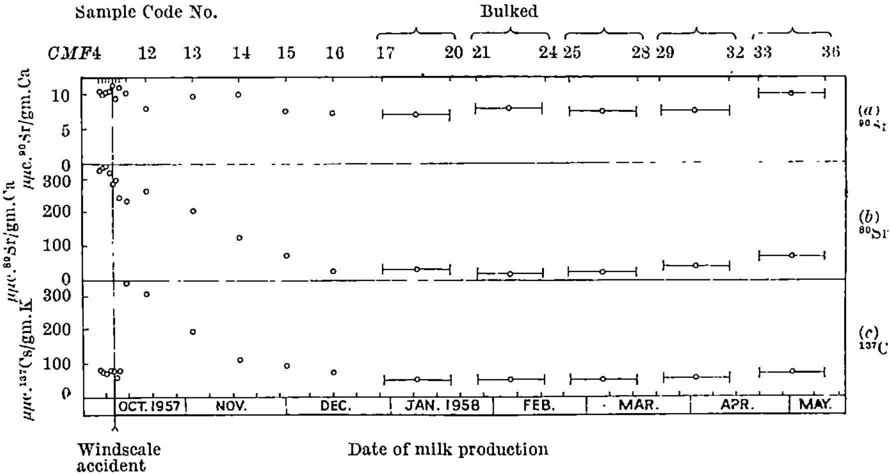

Fig. 4. Levels of fission products in cows' milk from west Cardiganshire, Wales, October 1957 to May 1958. All the values shown are accurate to within ± 10 per cent

Table 2. (*a*) STRONTIUM-90 AND CÆSIUM-137 LEVELS FOR PRE-OCTOBER 1957 SAMPLES OF COWS' MILK (WALES)

Sample	Date produced	Strontium-90		Cæsium-137		
		$\mu\mu$c./gm. Ca (S.U.)	$\mu\mu$c./litre liquid milk	$\mu\mu$c./kgm. dried skimmed milk	$\mu\mu$c./litre liquid milk	$\mu\mu$c./gm. K
(1)	(2)	(3)	(4)	(5)	(6)	(7)
CMF 1	April 1956	6·9	8·4	1,143	114	74
CMF 2	December 1956	8·4	10·2	1,102	110	71
CMF 3	January 1957	7·1	8·7	895	89	58
Bryant *et al.* (ref. 1)	October 1956	8·0				
	December 1956	7·2				
Bryant *et al.* (ref. 2)	April–August 1957 (mean value)	7·0				

Columns 3 and 5 directly estimated from measurements. Columns 4, 6 and 7 derived from columns 3 and 5 assuming that 1 litre liqui milk: (i) contains 1·22 gm. calcium and 1·54 gm. potassium; (ii) provides 100 gm. skimmed milk powder.

(*b*) IODINE-131 LEVELS FOR OCTOBER 1957 SAMPLES OF COWS' MILK (WALES)

Sample	Date of milking	$\mu\mu$c./kgm. dried skimmed milk	$\mu\mu$c./litre liquid milk
(1)	(2)	(3)	(4)
CMF 9	10/10/57	$< 1 \times 10^3$	$< 1 \times 10^2$
CMF 10	11/10/57	$3{\cdot}8 \times 10^3$	$3{\cdot}8 \times 10^2$
CMF 11	13/10/57	77×10^3	77×10^2
CMF 12	19/10/57	32×10^3	32×10^2

Column 3 directly estimated from measurements; column 4 derived from column 3 assuming no loss in drying and same specific activity in whole and skimmed milk.

from the earlier values. Looking at Fig. 4,*a* it will be seen that neither during the week covering the Windscale accident, nor afterwards, was there any demonstrable increase in the strontium-90 content of the milk examined. The mean of the levels shown for October and November 1957 is 10·2 S.U., being slightly higher than the mean level of 7·6 S.U. for the subsequent months until April 1958. The value for May 1958 is again higher, 10·1 S.U., indicating a seasonal variation.

It will be seen that the levels found for strontium-90 in milk over the period 1955–58 have remained surprisingly steady. This suggests that the levels are not building up proportionately to the cumulative fall-out.

Strontium-89. The values for strontium-89 (Fig. 4,*b*) fall progressively from October 1957 until January 1958, the strontium-89/strontium-90 ratio decreasing from 30 to 4 over this period. Similar effects were found by Bryant *et al.*[1] in samples produced in October and December 1956, and, as suggested by these workers, the results may be due to a change-over from fresh grass to stored fodder depleted in strontium-89 by natural decay (half-life = 54 days).

It appears from the present series that the average strontium-89/strontium-90 ratio during October 1957 was above 20. This figure may be compared with the average monthly ratios found by Stewart *et al.*[13] in rainwater at Milford Haven over the period May 1954–May 1957. These values range from less than 1 to a maximum of 45. On the other hand, owing to the short half-life of strontium-89, the strontium-89/strontium-90 ratio computed for the total fall-out accumulated on the ground has never exceeded a value of 2. Our average monthly ratio exceeding 20 in milk indicates that a significant fraction of the strontium-90 in milk is derived from fall-out of fairly recent origin. This result is in keeping with the view that the levels of strontium-90 in milk depend on the rate of fall-out and do not rise in proportion to the cumulative fall-out.

Cæsium-137. The levels of cæsium-137, both i samples produced immediately before the Windscal accident and after December 1957, are close to thos found in our three 1956 samples (Table 2,*a*). Simila values were obtained by Booker[3] for Welsh mill sampled in October 1956. Excluding the rise immediately after the Windscale accident these results follow the pattern for strontium-90, namely, that the level due to fall-out have remained steady. It is interesting to note that, as for strontium-90, the levels of cæsium 137 in the present Cardiganshire series are approximately double those reported for Somerset during 1955–56 [3].

Effect of the Windscale accident on the levels o cæsium-137 *and iodine*-131. The area from which th present series of samples is drawn is approximatel 160 miles south-south-west of Windscale. At th time of the accident our arrangements for gamma scintillation spectrometry were incomplete, but w were able to set up rapidly the single-channel system described above and to carry out measurements directly on dried milk samples (0·5–1 kgm.) a few days after the accident. This system was used for measuring the levels of iodine-131 in three samples produced shortly after the accident. This radionuclide was identified by observation of a peak appearing at 360 keV. combined with estimations of half-life. The results of these measurements are listed in Table 2,*b*. It will be seen that, although the cloud avoided north Wales[14], in south Wales some deposition occurred. Further measurements with the single-channel system demonstrated in samples produced immediately after the Windscale event a pronounced rise in gamma-activity in the 600–700 keV. band. It was not possible for us to analyse this activity in detail, but the evidence to hand suggests that about one-half of the activity was due to short-lived gamma-emitters, the observed 'half-life' being in the region of 2 months. (This activity is probably to be ascribed to zirconium-95 and niobium-95 [16].) The remainder of the activity was due to cæsium-137, identification being made by precise measurements using the 99-channel analyser system when the samples were at least nine months old. The values shown in Table 2,*a* and Fig. 4,*c* obtained on this system are based on spectral curves as illustrated in Fig. 5,*b*.

Our results illustrate the transient nature of the increase, due to the accident, of the activity occurring in milk. This is particularly well shown for cæsium-137, where the levels had returned to pre-accident values some two months afterwards. The progressive decrease in levels (Fig. 4) is similar to that found for strontium-89 over the same period and may be related partly to the change-over in the cows' feed during winter. It is noteworthy that the cæsium-137 level

Table 3. STRONTIUM-90, STRONTIUM-89 AND CÆSIUM-137 IN SAMPLES OF HUMAN MILK

Sample	Date collected	$\mu\mu$c. Strontium-90		$\mu\mu$c. Strontium-89		$\mu\mu$c. Cæsium-137		
		Per gm. Ca in ash (*a*)	Per litre liquid milk	Per gm. Ca in ash (*a*)	Per litre liquid milk	Per gm. ash (*b*)	Per gm. K in ash (*a*)	Per litre liquid milk
HM 1	Sept. 4–19, 1957	< 1·5	< 0·3	< 10	< 2	5·0	19	11·4
HM 2	Sept. 27–Oct. 11, 1957	< 0·5	< 0·2	< 5	< 2	4·0	21	9·9
HM 3	Oct. 15–28, 1957	—	—	—	—	4·6	21	10·3
HM 4	Oct. 12–20, 1957	—	—	—	—	4·9	20	9·4

(*a*) Calcium and potassium content measured for individual samples; (*b*) in our experience, less than 20 per cent of the total cæsium-137 present in milk is lost during ashing at 600° C.

for May 1958, although showing a slight rise above the winter values, is still close to the pre-accident level. This indicates that the activity released during the accident is no longer being incorporated in the grass.

The ratio of iodine-131 to cæsium-137 in our sample produced on October 13, 1957, was 20, lying between values reported for airborne activity on October 11 by Stewart *et al.*[14] (9·0) and Chamberlain *et al.*[15] (38·5). The increases in absolute levels in Cardiganshire were considerably smaller than those reported at Windscale. Thus, the iodine-131 value found by us on October 13 was less than 1 per cent of the highest level (1·4 μc./litre) found in the Windscale area (October 13, at a farm 10 miles from the works)[16]. There is little doubt, however, that the increases measured for Cardiganshire were a result of the accident and not a result of fall-out from distant bomb tests, which would have produced a corresponding increase in radiostrontium-levels.

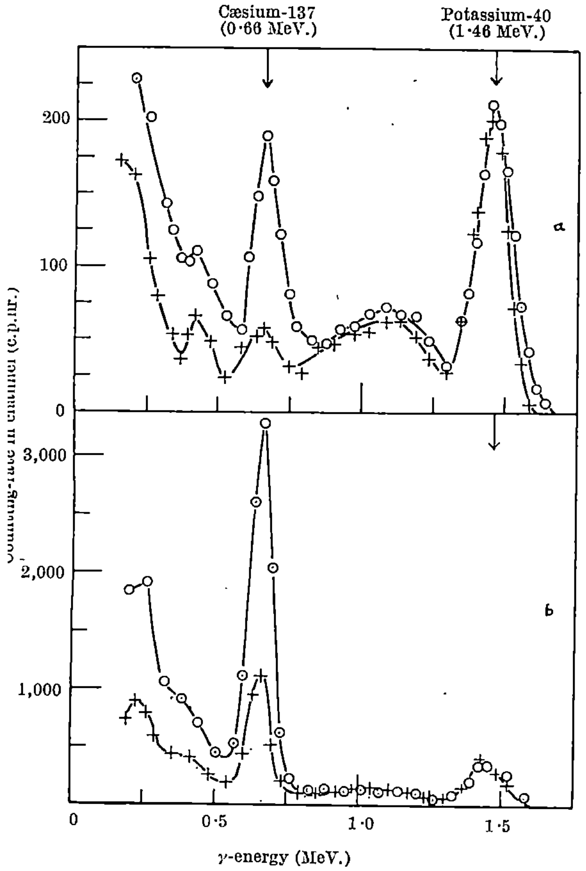

Fig. 5. Typical gamma-spectra of milk samples, determined in July 1958, using 99 channel analyser and low background (NaI(Tl)) crystal assembly.
(*a*) (i) Ashed cows' milk *OM* 8 15·5 gm. (pre-1945) (+); (ii) ashed human milk *HM* 3 13·3 gm. collected October 1957) (○). (*b*) (i) Dried cows' milk *CMF* 4 451 gm. (dried 6/10/57) (+); (ii) dried cows' milk *CMF* 12 420 gm. (dried 20/10/57) (○). (All spectra corrected for instrument background)

Measurements on Human Milk

We have made observations upon four samples of human milk, ranging in volume from 2·5 to 6 litres. Each sample was obtained from an individual donor and was collected over a period of a few weeks during September and November 1957. On receipt the milk was reduced to dryness and then to ash. Gamma-spectra were obtained for these ashed samples using the multichannel analyser, and in each case the photopeak of cæsium-137 was found at 660 keV. A typical spectrum is shown in Fig. 5,*a*, in comparison with a spectrum obtained from a pre-1945 sample of cows' milk ash. Estimated activities in the samples are given in Table 3. Two of the samples were analysed for radiostrontium but it was not possible to detect any such activity. The values for strontium-90 and strontium-89 shown in Table 3 are upper limits based on the limiting sensitivity of the method.

We are not aware of previous measurements of cæsium-137 in human milk. The levels we have found (expressed as μμc./gm. potassium) are similar to those observed in cows' milk from Somerset[3] and about one-third of the values in our Cardiganshire series. It is interesting to note that these levels in human milk are very close to those reported by Rundo (20–48 μμc./gm. potassium)[17] for total body measurements on human subjects during 1956–57.

In summary, it will be seen that our measurements of the levels of activity of fission products in milk are, where comparable, in good agreement with those previously published. It was possible to detect a small transient increase of iodine-131 and cæsium-137 levels in south Wales following the Windscale accident. It appears, however, that over three years the level of strontium-90 has remained fairly steady. Small changes have occurred but those which have so far been observed are unlikely to be biologically significant.

These investigations are being continued and extended to include other, short-lived, radionuclides and a wider range of biological materials. Throughout, attention is being directed to a comparative study of the levels of artificial and naturally occurring radionuclides.

We wish to thank Dr. A. L. Provan of the Milk Marketing Board for his collaboration in our sampling programmes. Thanks are also due to Mr. W. Binks, director, Radiological Protection Service, for permission to use a multi-channel analyser.

Valuable assistance was given by Mr. H. J. D. Ireland in the development of the counting equipment, and by Miss A. Dulley and Mr. D. Smith in the estimations.

The investigations were supported by grants from the Medical Research Council.

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THE LOCAL SUPERCLUSTER OF GALAXIES

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IN 1946, G. Gamow[1] advanced the speculative hypothesis that, possibly, " . . . the realm of galaxies . . . represents only a small part of a much larger system (a 'super-galaxy' in the super-Shapley sense) rotating around a distant centre", perhaps " . . . located far beyond the reach of our telescopes". As a test of this hypothesis, he suggested a search for a double-sine periodicity, similar to the Oort effect of stellar radial velocities in the Galaxy, in the radial velocities of external galaxies.

In 1951, Mrs. V. Cooper-Rubin[2] analysed the available velocities of about one hundred galaxies and found evidence for such an effect; the expected alternation of positive and negative residual velocities (after correction for solar motion and a linear red shift) was best displayed along a great circle of the sphere the pole of which was located at galactic co-ordinates $l = 14°$, $b = +10°$. This was taken to define a 'universal' plane of rotation, and tentative rotational constants were derived for the 'universe'. The direction of the centre was placed near $l = 104°$, $b = +5°$ or 180° from this position.

In 1952, K. F. Ogorodnikov[3] carried out a similar analysis with widely different results: the pole was located near $l = 110°$, $b = 0°$, and the direction of the centre was near $l = 20°$, $b = +88°$. It now appears that these early studies were confused by the use of a first-order theory based on the arbitrary assumption that the rotating super-system of galaxies must be identical with the whole 'universe' or 'metagalaxy'.

In 1953, I pointed out[4] (as others[5,6] had done before) the apparent concentration of galaxies brighter than about 15th magnitude towards and along a great circle of the sphere the pole of which was placed at $l = 15°$, $b = +5°$ (Fig. 1). Earlier statistical studies[7,8] had

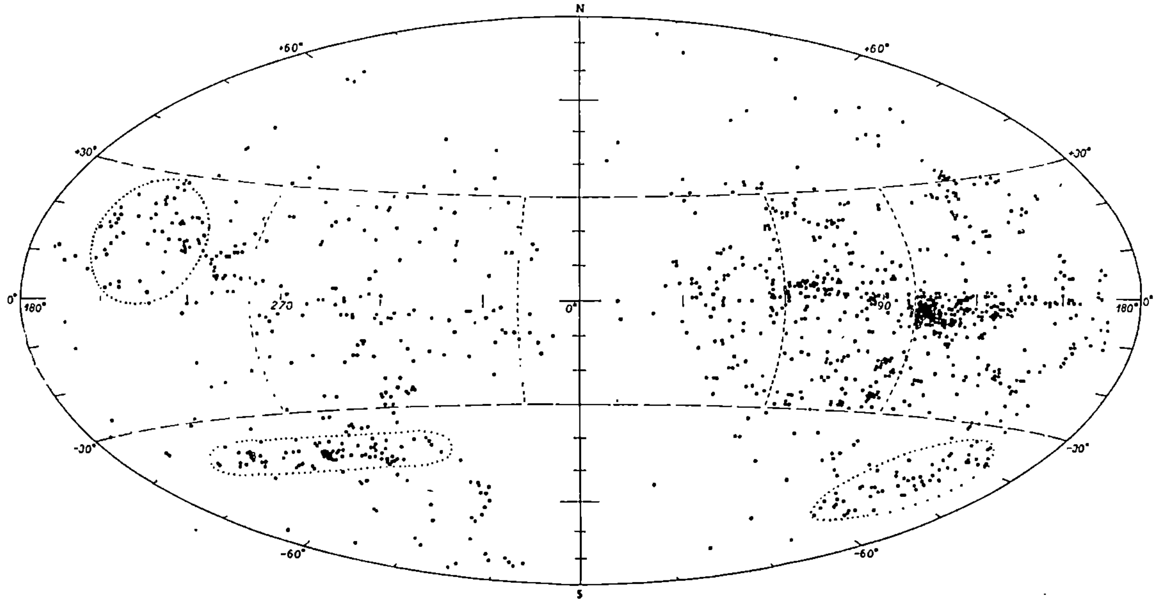

Fig. 1. Distribution in supergalactic co-ordinates of the brighter galaxies ($8{\cdot}0 \leq m_{pg} \leq 12{\cdot}9$). The northern galactic hemisphere is to the right; galaxies of known velocity are denoted by filled circles; those of unknown velocity, by open circles. Note that the majority of the galaxies lie between latitudes ± 30°. Three probable external supersystems are outlined by dots. The two critical longitude sectors discussed in the text are delimited by short dashes

indicated the presence of a large 'metagalactic' cluster or supercluster in our neighbourhood with a centre in the general direction of the north galactic pole, but they had received little attention. I therefore suggested that this 'Milky Way' of galaxies is the trace of a local super-system of clouds and clusters of galaxies—a local Supergalaxy—within which the local group of galaxies (including our own) is located, rather far away from a centre placed in or near the great Virgo cluster of galaxies at $l = 255°$, $b = +75°$.

Further study[9] indicated an overall diameter of 6–8 megaparsecs on the old (1936) distance scale, corresponding to about 30 megaparsecs on the current scale. The distance of the Virgo cluster is 10–13 megaparsecs in this revised scale.

The strong flattening of the system (axial ratio 1 to 5) was from the beginning[4,9] taken as supporting evidence for the hypothesis of a general rotation. Rotation, in fact, constitutes the critical test of the reality of the super-system as a physical unit held together by its self-gravitation; for in the absence of rotation the singular distribution of the nearer galaxies would have to be regarded as not significant, merely a chance grouping of a number of independent clouds and clusters.

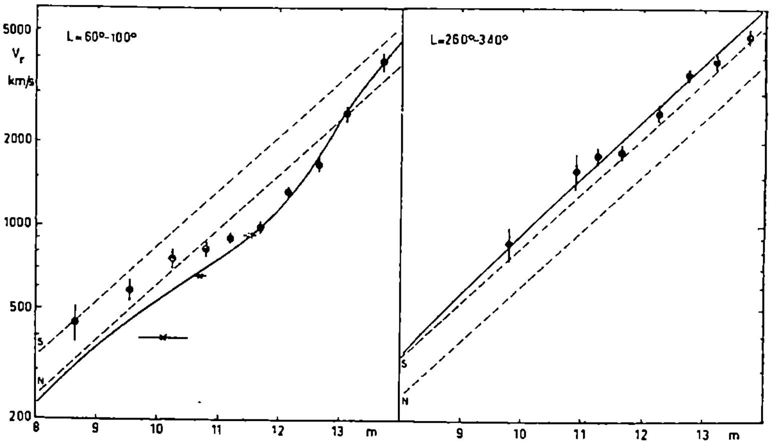

Fig. 3. Mean radial velocities of galaxies in the supergalactic equatorial belt as a function of magnitude in two longitude sectors. The theoretical curves are computed from the model described in the text. The dashed lines are the solutions for uniform expansion in the northern and the southern galactic hemispheres, according to Sandage. The crosses (left) give the mean magnitude $\bar{m}(V_r)$ in three velocity ranges to illustrate regression effects

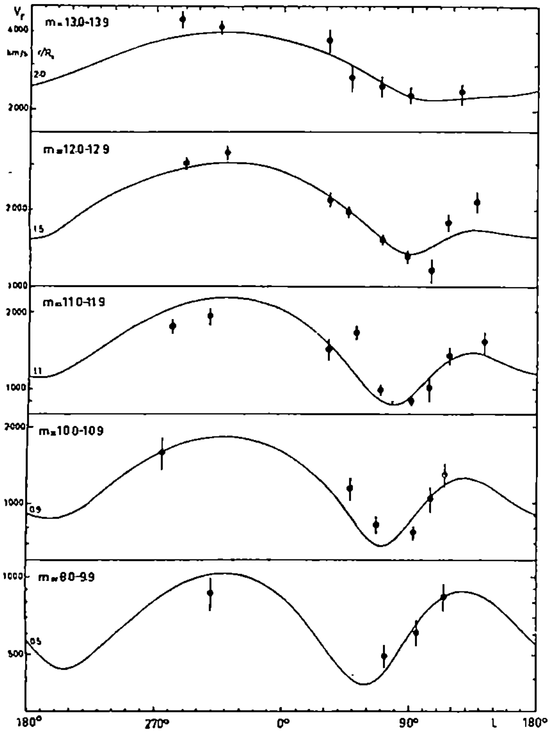

Fig. 2. Mean radial velocities of galaxies brighter than the 14th magnitude as a function of supergalactic longitude. The mean points with their probable errors refer to more than 300 galaxies within ± 30° of the supergalactic equator. The theoretical curves are computed from the model described in the text

A critical check has become possible through the publication in 1956 of the Lick – Mt. Wilson – Palomar general catalogue of radial velocities of galaxies[10]. Fig. 2 and Fig. 3 show the main results of an analysis of the radial velocities of more than 300 galaxies brighter than the 14th magnitude and located within 30° of the supergalactic equator.

In Fig. 2 the mean radial velocities are plotted as a function of supergalactic longitude L for 5 intervals of apparent magnitude. The mean points disclose a conspicuous, systematic longitude effect which, at small distances (small m), approximates the double-sine wave expected in a system in differential rotation.

In Fig. 3 the mean radial velocities are plotted against apparent magnitude for two critical longitude sectors. In the sector $260° \leqslant L \leqslant 340°$, corresponding to the supergalactic anti-centre sector (and to the southern galactic hemisphere), the relation between $\log V_r$ and m is approximately linear; in the other sector, $60° \leqslant L \leqslant 100°$ (near the north galactic pole), the non-linearity is conspicuous; further, the mean velocities at a given apparent magnitude (hence, at a given distance) are widely different in the two sectors.

This discrepancy had already been noted by Sandage[10] as a puzzling effect detracting from the usual assumption of isotropy. The conclusion seems inevitable that, contrary to orthodox theory, the red shift is neither linear nor isotropic among the brighter galaxies; the results are, however, consistent with and easily interpreted by the Supergalaxy hypothesis.

We assume that the local supercluster is in a state of differential rotation and differential expansion about its centre in the Virgo cluster. The first assumption does not require amplification; the second, which accounts for the north-south asymmetry, is made the more plausible by a variety of theoretical and empirical arguments suggesting that in condensed regions of space (groups, clusters) the expansion rate is reduced locally by gravitational attraction; for example, the Galaxy and the local group are probably not expanding. On these assumptions, the radial velocity of a galaxy in longitude L at distance r from us, and R from the centre of rotation, is given by the classical relation:

$$V_r = R_1[\omega(R) - \omega_1]\sin(L - L_0) - R_1[\varepsilon(R) - \varepsilon_1]\cos(L - L_0) + \varepsilon(R)\cdot r \qquad (1)$$

For the purpose of computing a simple model it is assumed that the angular velocity, $\omega(R)$, and the expansion-rate, $\varepsilon(R) = R'/R$, are of the forms:

$$\omega(R) = \omega_0 \exp(-R/R_1)^2 \qquad (2)$$

$$\varepsilon(R) = \varepsilon_\infty[1 - \exp(-R/R_1)] \qquad (3)$$

if R_1 is the distance of the Galaxy to the centre in longitude L_0.

Note that the only free parameter for adjustment to the observations is the rotational velocity, $R_1\omega_1 = R_1\omega(R_1)$, of the Galaxy, since all others are determined uniquely in our hypothesis by the longitude, $L_0 = 104°$, and the radial velocity, $\varepsilon_1 R_1 = +1{,}100$ km./sec., of the Virgo cluster. Further, the auxiliary relation between apparent magnitude m and distance r is also given by the Virgo cluster where $\overline{m} = 11 \cdot 5$ at $r = R_1$.

As shown by the computed curves in Figs. 2 and 3, excellent agreement is obtained if $\omega_1 R_1 = 500$ km./sec. (with an estimated probable error of ± 50 km./sec. The values of r/R_1 range from 0·5 to 2·0 as m increases from 8–9 to 13–14; this large range makes it clear why a first-order theory is inapplicable, quite apart from the complication of the non-linear expansion.

From the rotational velocity we derive the total mass of the supersystem, $M(\text{tot.}) \approx 10^{15}$ solar masses (assuming a modulus $m_0 - M = 30 \cdot 0$, $R_1 = 10$ Mpc.). This appears to be a reasonable value when compared with estimates of the mass of the Virgo cluster, $M(\text{nucleus}) \approx 10^{14}$ solar masses, based on velocity dispersion[16].

This analysis supports the conclusion that the local supercluster of galaxies is an irregular assembly of groups, clouds and clusters dominated by the Virgo cluster in its centre, and that it has reached at least some degree of dynamical equilibrium involving rotation, expansion, and random motions. The Galaxy partakes in the slow general rotation of the system with a velocity of the order of 500 km./sec. directed towards $L = 194°$ ($l = 287°$, $b = -14°$). The present or 'instantaneous' period of revolution is of the order of 5×10^{10} years near the centre, and from 10 to 20×10^{10} years in the outer regions.

The presence of differential expansion in the local super-system has an important consequence for the calibration of the law of red shifts, namely, the derivation of Hubble's expansion parameter, $H = V_r/r$. This is customarily done simply by dividing the velocity by the distance of the Virgo cluster, because it is the only one with both a significant red-shift and a distance small enough to be within the range of comparatively reliable distance indicators; with present 'best' estimates[12], $V_r = +1{,}136$ km./sec., and $m - M = 30 \cdot 7$, $H = 83$ km./sec. per Mpc. However, from equation (3), it follows that the apparent recession-rate of the Virgo cluster is $\varepsilon_1 < \varepsilon_\infty = H$. In the model above, $\varepsilon_1 = 0 \cdot 632\varepsilon_\infty$, so that if $R_1\varepsilon_1 = 1{,}100$ km./sec. and $R_1 = 10$ Mpc., $\varepsilon_\infty = 174$ km./sec. per Mpc.; if $R_1\varepsilon_1 = 1{,}136$ km./sec. and $R_1 = 12 \cdot 6$ Mpc. (modulus 30·7 less 0·2 mag. local absorption correction), $\varepsilon_\infty = \mathrm{H} \approx 140$ km./sec. per Mpc.

Another consequence of differential rotation and expansion is that, in deriving the mean absolute magnitudes of galaxies from residuals of the velocity – magnitude relation, it is necessary to take account of the non-linearity and anisotropy of the velocity field. Details will be published shortly in the *Astronomical Journal*.

Although the philosophical notion of second-order clustering is an old one[13], the general existence of super-clusters of galaxies has only recently been demonstrated (and it is not yet universally accepted), mainly through the statistical analysis of counts of faint galaxies at Lick[14,15] and of clusters of galaxies at Palomar[16]. G. Abell[17] has recently reported preliminary estimates of the average size of some distant super-clusters which (on the same distance scale) agree well with the estimated diameter of the local supercluster.

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MIOCENE MAMMALIA FROM THE NAPAK VOLCANICS, KARAMOJA, UGANDA

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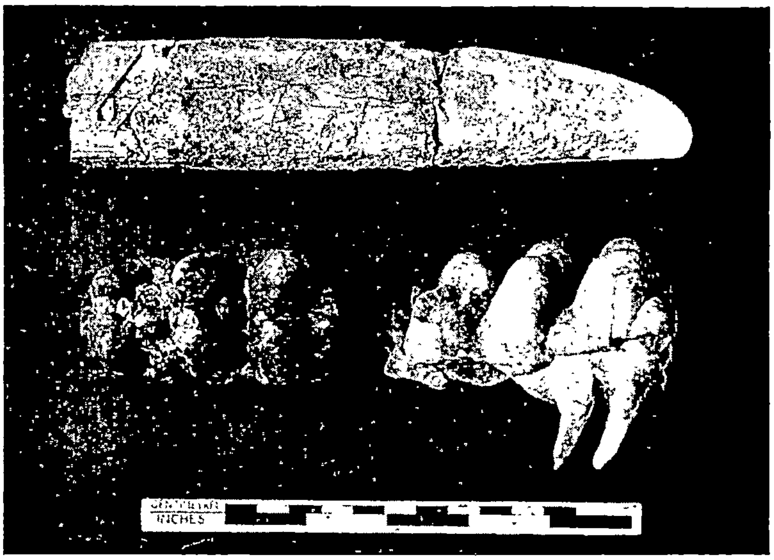
THE mountain mass of Napak in Karamoja District, north-east Uganda (2° 5′ N., 34° 17′ E.) is the dissected remnant of a Tertiary volcanic cone in the group that includes Elgon, Kadam, Moroto and Toror (Fig. 1).

Mammalia were recorded from Napak as early as 1920 by E. J. Wayland but were not identifiable[1]. In 1957, eight fossils were forwarded to the Geological Survey by J. G. Wilson, an officer of the Agricultural Department. Dr. A. F. Trendall of the Geological Survey reported that detailed work might prove rewarding and as Wilson's specimens included a shattered proboscidean molar and a well-preserved rodent skull I went to the area early in 1958.

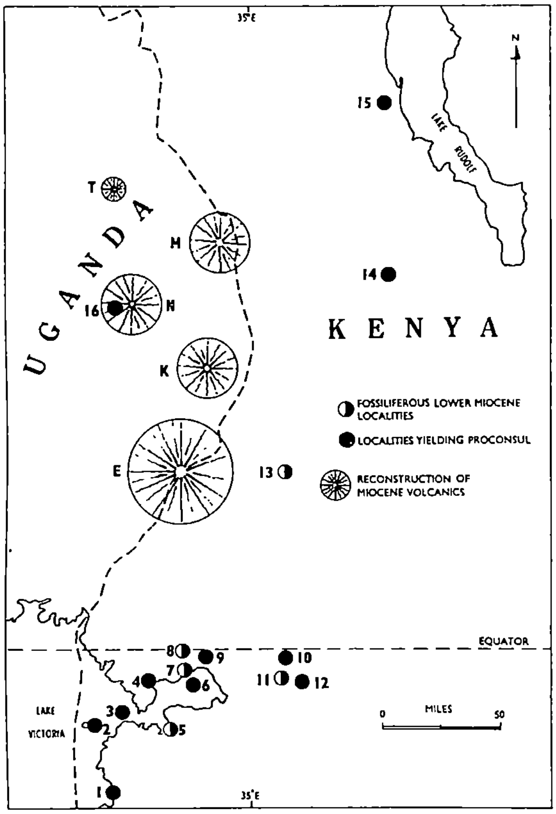


Photograph: *Uganda Museum*

Fig. 2. Molars and tusk of *Trilophodon angustidens*

Three fossiliferous localities have been located but only the main site is described here. This is situated at a radial distance of six miles south-west of the carbonatite and ijolite plug which marks the position of the central vent. The fossiliferous beds are a series 100 ft. in thickness of horizontally bedded, unconsolidated fine grey tuffs with occasional agglomerate bands. The beds overlie a lava and thick coarse agglomerate and are in turn overlain by further agglomerate. The base of the fossiliferous series occurs at a height of 4,480 ft. O.D. and is 500 ft. above the basement rocks at this point. The beds are of only limited extent and owe their origin to the existence of a subsidiary vent, now represented by an agglomerate plug, which blocked a shallow valley on the flanks of the main volcano. Into the hollow so formed, fine detritus was washed, and ash and agglomerate were deposited by minor outbursts of activity. The hollow may have held water for short periods after heavy rainfall.

Local non-sequences and reddened surfaces, the occurrence of abundant fossil wood and the presence of layers of calcareous nodules (kunkar), flags with rain-spotting, and layers of curled, sun-dried mudstone, give evidence of numerous breaks in deposition. The fossils occur sparingly upon these temporary land surfaces.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FOSSILIFEROUS LOWER MIOCENE LOCALITIES
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RECONSTRUCTION OF MIOCENE VOLCANICS
EQUATOR
8
9
10
7
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12
LAKE VICTORIA
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0 MILES 50
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Fig. 1. Distribution of fossiliferous Lower Miocene deposits and the genus *Proconsul*. 1, Karungu; 2, Mfwangano; 3, Rusinga; 4, Uyoma; 5, Homa; 6, Maboko; 7, Majiwa; 8, Mariwa; 9, Ombo; 10, Songhor; 11, Muhoroni; 12, Koru; 13, Suk escarpment; 14, Loperot; 15, Losodok; 16, Napak; *E*, Elgon; *K*, Kadam; *N*, Napak; *M*, Moroto; *T*, Toror

To date the site has yielded 1,114 mammalian fossils. Of these, 778 are unidentifiable fragments of bone and tusk, many of which show marks of the teeth of carnivores. The remaining 336 pieces are made up as follows: 39 fragments of proboscidean teeth, including four well-preserved molars, and 45 fragments of tusk (Fig. 2); 35 pieces of rodent skull, jaw and teeth; 29 fragments of skull, jaw and teeth of various Primates, Carnivora, Artiodactyla and Perissodactyla; and 188 bones with distinct facets or form which are probably identifiable.

From a preliminary examination the following mammalia have been tentatively listed as occurring; *Proconsul nyanzae* (Le Gros Clark and Leakey); *Limnopithecus* sp.; Lemuroidea; Histricomorpha; Pedetidae; Anomaluroidea; *Pterodon* sp.; *Amphicyon* sp.; Carnivora; Suidae; Tragulidae; Chalicotheriidae; *Trilophodon angustidens* var. *kisumuensis* (Macinnes); Gastropoda (indet.); abundant fossil wood and occasional leaf impressions.

I am indebted to Mrs. S. Coryndon and to my wife for help with identification, and to Dr. L. S. B. Leakey, curator of the Coryndon Museum, Nairobi, for permission to study comparative material from Kenya and for the following note.

"I have made a preliminary examination of the better preserved fossils found by Dr. Bishop and they are of exceptional interest. Although the collection is small it includes enough typical forms to leave no doubt as to its affinities with the Lower Miocene faunas from Rusinga, Mfwangano, Songhor, Koru and the Lake Rudolf areas of Kenya.

"Of special interest is the presence of *Proconsul nyanzae* and the genus *Limnopithecus*. The former is represented by a very beautifully preserved and quite typical lower right second molar (Fig. 3) while the latter is part of the mandible in which the preservation is less good. There is no doubt that it represents the genus *Limnopithecus* and is probably referable to the species *legetet* but without a better specimen this cannot be stated with certainty."

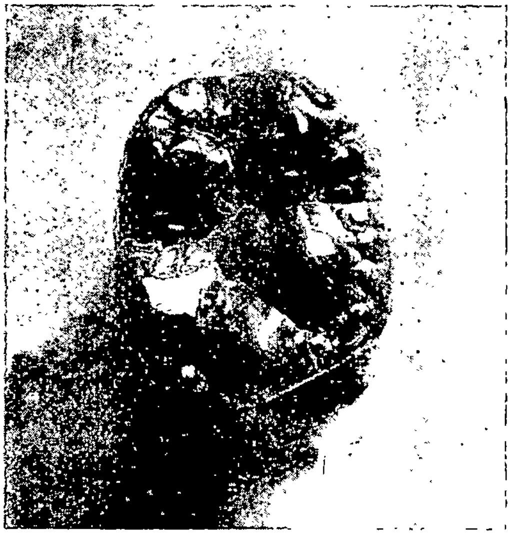

Fig. 3. Lower right second molar of *Proconsul nyanzae*. Maximum length, 12 mm.; maximum width, 10 mm.; posterior edge of tooth at bottom of photograph. Photograph: L. S. B. Leakey

The quantitative analysis of the fauna reveals several points of interest. The action of carnivores as scavengers is seen in the numerous chewed bones and also in that 13 per cent of the fragments surviving as fossils are comparatively inedible teeth and jaws. The specimens are invariably broken or chewed before incorporation in the tuff and are never found as associated skeletons. This suggests that the animals died from natural causes or as a result of the action of predators and were not overcome by gases or ejected material during active periods of the volcano.

The most abundant group numerically were the Rodentia, which account for 23 per cent of all the teeth, jaws and skull fragments recovered. An abundance of rodents is also characteristic of the Kenya Lower Miocene.

The occurrence of fossil wood confirms that the non-sequences in the tuff represent periods when the lower slopes of the volcano became clothed temporarily with vegetation and provided a suitable habitat for the Hominoidea, Lemuroidea and Anomaluroidea.

The genus *Proconsul* is now known from ten major localities in western Kenya but this is the first record from Uganda. The distribution of the main localities yielding *Proconsul* together with the principal outcrops of fossiliferous Lower Miocene deposits is shown in Fig. 1.

The Napak material has been submitted to specialists for specific identification, and a full account of the fauna, stratigraphy and geomorphology of the site will be published at a later date. However, there seems little doubt of the similarity between the assemblage and the extensive faunas obtained from the numerous sites in the Kavirondo area of Kenya, 145–170 miles south of Napak. This material, with certain reservations, is at present considered to be of Lower Miocene Age and is equated with the European Burdigalian[2].

The Napak fossils occur in a simple stratigraphical context in a single volcano resting upon extensive peneplained surfaces developed upon steeply dipping Basement Complex rocks. Thus the deposits have a geomorphological importance in their relationship to former erosion-levels which is absent in the Kenya deposits, where large-scale rift movements and local faulting have frequently disturbed the Lower Miocene deposits and obscured their relationship to pre-volcanic surfaces. The importance of the faunal dating of the volcanics is threefold:

1. It establishes a Lower Miocene age for the early activity at Napak and possibly also at the associated volcanoes of Toror, Moroto, Kadam and Elgon. Despite their varying degrees of erosion these have previously been considered as broadly contemporary with Napak and of Pliocene age[3,4].
2. It provides an approximate morphological time-scale for the building up of the predominantly ash and agglomerate cone to about 10,000 feet above the Basement Complex[3], and its subsequent erosion to the present series of isolated hill remnants.
3. It dates the sub-volcanic surfaces of Napak and probably also those beneath Toror, Moroto, Kadam and Elgon as of Pre-Miocene age. It is possible that the more advanced erosion of Napak and Toror may indicate a rather earlier origin than Elgon, Moroto and Kadam. However, I agree with Trendall[5] that it is more likely that the degree of dissection is related to differences in original bulk of the volcanoes and their position in relation to the base-level of erosion and to major watersheds. Their approximate contemporaneity is supported by the similarity in height and form of the basement surfaces beneath Napak, with those of Moroto, Kadam and Elgon. Two major erosion-levels appear to be represented:

(*a*) An upper surface with the following average heights: Moroto 4,900 ft.; Napak 4,900 ft., Kadam 4,900–5,000 ft., Elgon 5,400–6,000 ft.[5-7], which appears to be the equivalent of the Pre-Miocene, Mid-Tertiary, Mid-Miocene, Buganda, Uganda, Middle or Main peneplain of various authors. This level was already being dissected, at the time of commencement of the eruptions, by a lower surface developing at the expense of the upper one and separated from it by an escarpment of almost 1,000 ft.

(*b*) This lower surface occurs at the following average heights: Napak 3,800–4,100 ft., Kadam 3,900–4,100 ft., Elgon 3,500–3,700 ft.[4,5]. This 'Kyoga Surface' of Trendall appears to differ little in height and morphological relationships from the 'End Tertiary' surface of various authors. In eastern Uganda it has been little modified by the formation of the present-day 'Karamoja Plain', which descends gradually towards the south-west from heights of 3,900 ft. at Napak and Kadam and 3,600 ft. north of Elgon[4,6]. This surface has in its turn been only slightly incised by the present drainage, which flows to the local base-level of the Lake Kyoga system at 3,400 ft. O.D.

The lower surface may not be the true time equivalent of the 'End Tertiary' surface elsewhere but the fauna of Napak necessitates at least a local re-dating of the Buganda and Kyoga surfaces as being considerably Pre-Miocene, and slightly Pre-Miocene, respectively. The lack of downcutting into the Kyoga surface in post-Miocene time is remarkable and may well be related to the warping which initiated the Victoria-Kyoga lake system as an extensive 'local' base-level.

This article has been submitted for publication by permission of the Director of the Geological Survey of Uganda.

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OBITUARIES

Prof. James Ritchie, C.B.E.

Born in 1882 at Port Elphinstone, Aberdeenshire, the son of the local schoolmaster, James Ritchie, emeritus professor of natural history in the University of Edinburgh and president of the Royal Society of Edinburgh, died suddenly in Edinburgh on October 19 at the age of seventy-six. He had a notable career. Educated at Gordon's College and then at the University of Aberdeen, he joined the staff of the Natural History Department of the Royal Scottish Museum in 1907. Assistant keeper in 1919, he succeeded Dr. Eagle Clarke as keeper of the Department in 1921, but nine years later was appointed to the regius chair of natural history in the University of Aberdeen, following Sir J. Arthur Thomson, under whom he had been trained. In 1936 he returned to Edinburgh as professor of natural history, retiring in 1952. He was elected president of the Royal Society of Edinburgh in 1954.

It was highly fitting that the posts James Ritchie occupied were all designated, as largely remains the custom in Scotland, 'natural history'. He was, above all else, a naturalist, and no one had a better knowledge of the fauna of his country, both in the present and in the past, and more concern for its future. He published extensively and over an exceptionally wide field, ranging from marine hydroids and polyzoans to birds and mammals, and also made notable contributions to archæology, an interest he gained from his father, an earlier James Ritchie and a well-known amateur archæologist. He wrote three books, "The Influence of Man on Animal Life in Scotland" (1920), "Beasts and Birds as Farm Pests" (1931) and "Design in Nature" (1937).

The first of these represents his major contribution—and it is a great one—to knowledge of animal life in Scotland. It may be described as a work of scholarship written by a born naturalist. Ritchie had the advantage, which he stressed, of dealing with a small country and with the changes in the purely post-glacial fauna which neolithic man found when, some 9,000 years ago, he followed the northward migration of these animals into Scotland. He had the further advantage of the recorded observations of many generations of Scottish naturalists, of whom he was the worthy successor and ideal interpreter. This book had great influence on the growth of the youthful science of animal ecology, with its applications in conservation. It won international recognition for its author, including an award of a silver medal by the Société Nationale d'Acclimatation de France.

His investigations and advice were largely responsible for measures of protection for both seals and birds in Scotland. He found, by examination of the contents of caves near Inchnadamph in Sutherland, evidence of an arctic fauna with indications of the presence of palæolithic man. In archæology, his long and extensively illustrated account of the lake dwellings in Loch Treig is a classic description, and he was engaged on further work of this type at the time of his death.

Ritchie's activities were as wide as his interests. From its first inception in 1909, he took a great part in the development of the Royal Scottish Zoological Society, of which he became vice-president; he was secretary and later president of the Royal Physical Society; vice-president of the Scottish Marine Biological Association; chairman of the Council of the Royal Scottish Geographical Society; president of Section *D* (Zoology) of the British Association in 1939. He was for fourteen years editor of the *Scottish Naturalist* and was the natural choice as chairman of the Scottish Wild Life Conservation Committee which prepared the way for the establishment of the Scottish Committee of the Nature Conservancy, of which he was an initial member. Elected to the Royal Society of Edinburgh in 1916, he served many times on its Council, being secretary, later a vice-president and finally, in 1954, president. He was awarded the Keith Prize of the Royal Society of Edinburgh in 1944, was created C.B.E. in 1948 and received the honorary doctorate of laws from his own University of Aberdeen in 1952.

By his writings, his lectures to university students and to a wider public, and by his charming watercolour paintings of the Scottish landscape, James Ritchie was widely known, and his loss will be felt far beyond the circle of his friends and colleagues. He married Miss Jessie J. Elliot, who died in 1933, and is survived by his son, Prof. A. E. Ritchie, Chandos professor of physiology in the University of St. Andrews, and by his two daughters.

C. M. Yonge

Dr. T. A. Sprague

Dr. Thomas Archibald Sprague, well known as a taxonomic botanist and an authority on plant nomenclature, died at his home in Cheltenham on October 22, at the age of eighty-one

He took the degree of B.Sc. at Edinburgh, under Prof. Bayley Balfour. In 1898, he undertook, with Captain H. W. Dowding, R.N., an expedition to Venezuela and Colombia, and the first set of the plants he collected are at Kew. Sprague was appointed to the staff of the Herbarium of the Royal Botanic Gardens, Kew, in 1900, and for about two decades was in charge of the Thalamiflorae and Disciflorae (in the system of Bentham and Hooker). The division of work was, however, not strictly adhered to, and some of Sprague's best taxonomic work concerned the Loranthaceae of tropical and south Africa, for the "Flora of Tropical Africa" and the "Flora Capensis", respectively, and the Bignoniaceae. Later, he was in charge of the American collections. He made, with Mr. (later Dr.) John Hutchinson, a botanical excursion to the Canary Islands in the summer of 1913. He served with the artillery in the First World War and was stationed in India and did some plant collecting in the Punjab. Sprague was awarded the degree of doctor of science by the University of Edinburgh in 1930 and was, the same year, appointed deputy keeper of the Herbarium. He was a fellow of the Linnean Society of London from 1903, and on May 12, 1937, was presented with the Coronation Medal of George VI. He retired from his post at Kew on October 31, 1945.

Soon after his return from military service, Sprague devoted a large proportion of his official and private time to botanical nomenclature and to the study of certain herbals. Those who knew his careful critical researches on the systematics of various groups tended to regret that he did not concentrate on herbarium taxonomy in the form of monographic work. However, he was mentally and temperamentally well equipped to deal with modern revisions of old herbals and with the intricacies of nomenclature. His accounts of "The Herbal of Otto Brunfels" (*J. Linn. Soc. Bot.*, 48, 79; 1928) and, with E. Nelmes, of "The Herbal of Leonhart Fuchs" (*loc. cit.*, 48, 545; 1931) are models of their kind. For a good many years Sprague was in charge of compilers engaged in preparing the supplements (usually quinquennial) of the "Index Kewensis". There is no doubt that his training of these to the degree of accuracy on which he insisted greatly raised the standard of this important work. It is probable, too, that this supervision of an index to plant names directed his attention to botanical nomenclature in general and to various weaknesses in the International Rules. He attended the International Congress of Plant Sciences, held at Ithaca, New York, in August 1926 and read a paper there under the title "Principles and Problems of Plant Nomenclature". This clearly written paper (published in the Proceedings, 2, 1422; 1929) might be read with advantage by modern nomenclaturists. Sprague became a leader in plans for revision of the rules and largely directed the meetings and debates on this subject at the International Congresses of Cambridge (1930), Amsterdam (1935), and Stockholm (1950). His lucid mind and his undoubted liking for legal form enabled him to enjoy discussions which were sometimes prolonged and sometimes heated.

Sprague was very helpful in training young systematists at Kew, and, though he sometimes flared up rather quickly, he was always kind and painstaking, and anger died quickly and left no malice in him. He was twice married and leaves three children and a widow. After his retirement to Cheltenham he devoted a good deal of time to his hobby of collecting certain special makes of British ceramics and to the Cotteswold Naturalists' Field Club, of which he became president. W. B. TURRILL

NEWS and VIEWS

Jodrell Bank Radio Telescope Appeal

AN appeal was launched by the University of Manchester at the recent meeting of the Court of Governors for subscriptions to a fund for the radio telescope at Jodrell Bank. The appeal has now been issued over the signatures of Sir Raymond Streat (chairman), Mr. L. P. Scott (deputy chairman), Mr. A. V. Symons (treasurer), Mr. R. B. Barclay (deputy treasurer), and Prof. W. Mansfield Cooper (vice-chancellor). In consequence of the Russian *Sputnik* and the American *Explorer* satellites and lunar probe, all the world knows that the University of Manchester has pioneered in the construction of this 250-ft. steerable radio telescope capable of scientific research on a vast cosmological scale as well as studies of immense practical importance in radio communications and the tracking of satellites used for space exploration. When the building of the instrument was originally proposed, the Council of the University gave enthusiastic support to the ideas of the scientists. Undismayed by the large sums of money involved according to the first estimates—and the difficulties of estimating are obvious—the University embraced the project. The Nuffield Foundation and the Department of Scientific and Industrial Research agreed each to find £200,000. Later it was found essential to revise the first estimates and the Department contributed a further £130,000 on the assumption that the University would find donors willing to cover the balance. It now appears that the University will require at least £150,000 to relieve the telescope from debt and to set scientists free to pursue, without financial anxieties, work of the first order of importance and urgency. If a larger sum were obtainable, further and better work could be done. It is hoped to receive contributions not merely from firms whose products give them a technical and perhaps commercial interest in the work of the Telescope but also from firms, institutions and individuals who would not wish that the result of the University's courage in this matter should be to leave it with unsolved financial problems.

The radio telescope is an immense achievement whether viewed as a stupendous piece of scientific equipment conceived by Prof. A. C. B. Lovell, an unparalleled feat of engineering designed by Mr. H. C. Husband or a fine accomplishment by the many firms engaged on the project, especially the main contractors, the United Steel Companies, Ltd. The increases over the earliest estimates have been accepted as necessary in all the circumstances by both the Department of Scientific and Industrial Research and the University. Indeed, when the University first realized that heavy additional costs were involved, it was nevertheless decided to proceed with the instrument. In reaching this decision, the University relied on the most expert external advice, scientific and technical. As a consequence the instrument was ready to play the part it did in the International Geophysical Year and the developments which have stemmed therefrom. Had the University failed to proceed, Great Britain's contribution to recent world scientific events of great international importance would have been sensibly lessened. The ultimate costs would also have been greatly enhanced. The result of the University's courage is that Britain is first in the field with a telescope of fantastic quality at a cost far below what others will soon be paying for similar instruments. Before opening the appeal, £10,000 was received from Henry Simon, Ltd., and an offer of a further £10,000 from Simon Carves, Ltd. Several small subscriptions have been received from individual donors after Press accounts of the Court meeting. Contributions in the form of seven- or ten-year covenants will be especially welcome. The Bursar of the University will acknowledge donations or supply information to those considering alternative methods of giving support.

The National Research Development Corporation

THE Development of Inventions Bill, which received its second reading in the House of Commons on November 14, extends the power of the National Research Development Corporation to make advances by a further ten years from June 1959 onwards, and raises the limit on the amount of advances from £5 million to £10 million. In moving the second reading, the Parliamentary Secretary to the Board of Trade, Mr. J. Rodgers, explained that unless the former limit was raised, the Corporation would have to abandon many projects already in hand before they could come to fruition and might quite soon find itself unable even to discuss new projects with inventors or research organizations, however important their proposals. Mr. Rodgers also said that it is hoped in future to publish the annual report of the Corporation rather earlier. He referred to the contribution of the Corporation to the establishment of an electronic computer industry in Britain, and also mentioned its sponsoring of the flexible containers for transporting oil developed by research at the University of Cambridge. He said that the Corporation's income had now risen to nearly £200,000. Mr. A. Albu, in welcoming the Bill, mentioned among other new developments a new mechanism for storing energy in the flywheel of a commercial vehicle when braking and making the energy available afterwards for acceleration, and Sir Thomas Merton's diffraction gratings at the National Physical Laboratory, which will have increasing use in spectrometry and metrology. He believes the Corporation should use to the full its power to place development contracts, particularly for new processes or for new machines; that more use should be made of the section of the 1948 Act which enables the Government to ask the Corporation to undertake work which is not economic and for which it would make good a loss if the work was in the public interest; and that the Corporation would further develop its existing good collaboration with the universities and the colleges of technology.

Research and Development in Government Establishments

ANSWERING a question on November 18 in the House of Commons as to the availability of research equipment at the National Chemical Laboratory, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, on behalf of the Lord President of the Council, said that subject to the avoidance of undue interference with its own research programme, the Laboratory is always ready to consider how its resources of equipment and knowledge of special techniques can be utilized by other scientists from industrial laboratories. During the past two years, research workers from seven organizations have spent in all ninety days on experiments with special high-pressure and high-temperature equipment in the Laboratory, and this use is expected to grow. In reply to further questions about scientific and industrial research, Mr. Nicholls said that Government expenditure on scientific research for civil purposes has more than doubled since 1951, and this year the research councils for which the Lord President is responsible will be spending about £20 million, compared with less than £9 million eight years ago. The investigation at the Water Pollution Research Laboratory of the effects of industrial effluents on streams, with the object of developing improved methods of treatment, has been assisted by a contribution from industry through the Federation of British Industries which next year will amount to £13,000. The Pest Infestation Laboratory has developed a rapid and reliable instrument, now available commercially at a cost of about £50, for determining the moisture content of cereals stored in bulk, and the National Institute of Agricultural Engineering of the Agricultural Research Council has examined the range of moisture meters available for testing the moisture content of grain stored on the farm. The Road Research Laboratory is investigating means of electrically heating road surfaces to mitigate dangers from frost, and it is hoped shortly to lay another experimental surface of this type on a new road-bridge to be constructed at Slough. The work of the Laboratory on the design and siting of snow fences has been outstandingly successful and offers large savings of cost and labour if the snow fences are correctly sited. The British Coal Utilization Research Association has shown that with proper mechanical firing equipment the efficiency of use of small coal in shell-type boilers can be high. Further research and development on automatic handling and control are in progress, in association with the National Coal Board, which is also developing work on the manufacture of briquettes from small coal.

Science and Mathematics in Schools

IN answer to a question asked in the House of Commons on November 18, the Joint Under-Secretary of State for Scotland, Mr. N. Macpherson, said that according to estimates by the education authorities and managers of grant-aided schools, 97 teachers with first- or second-class honours degrees were required in October 1957 to teach science and 119 to teach mathematics. A further 152 graduate teachers were needed to teach these subjects in the junior classes of secondary schools. Representations for the release from National Service of third-class honours graduates in science and mathematics to enable them to return to the schools are under consideration.

Broadcasting, Television and the Schools

IN an address to the School Broadcasting Council on November 7, Sir Ian Jacob, director-general of the British Broadcasting Corporation, referred particularly to the dependence of Great Britain, and possibly its survival, upon the widest possible diffusion of scientific skills and knowledge. He suggested that the British Broadcasting Corporation might be able to make, in its own way, "a new and massive contribution to the understanding of science in the secondary modern schools, where the need perhaps is greatest and where the shortage of good teachers is likely to be most acute". Sir Ian said he had recently received a deputation comprising the Presidents of the Royal Society and the British Association and the Chairman of the Advisory Council on Scientific Policy, who had come to urge that the Corporation should do its best to interest the broad mass of the people in scientific development and to present science as vital to the well-being of our contemporary world. The B.B.C., he said, is already doing this job, and it proposes to put all the resources it can behind it. The task must begin in the schools, and Sir Ian thought that television might be opening up wholly new possibilities in school broadcasting.

Extensions to the Duncan Flockhart Research Laboratories, Edinburgh

EXTENSIONS to the Duncan Flockhart Research Laboratories in Edinburgh, which were opened on November 14 by Prof. John Bruce, president of the Royal College of Surgeons of Edinburgh, consist of additional development and biological laboratories. The former are in the chemical laboratory building, which also houses the analytical control department and the library. The new biological laboratories form part of a quadrangle of buildings in which biological research and assay are carried out. The extensions were designed by members of the staff, the principal contractor of laboratory furnishing being Nathaniel Grieve. Lord Ferrier, chairman of the T. and H. Smith Group of companies, of which Duncan Flockhart became a member in 1952, presided at the opening ceremony, and an address of thanks to Prof. Bruce was delivered by Dr. F. R. Smith, director of Duncan Flockhart and Co., Ltd., who is in charge of the Group's research and development activities.

The research staff includes chemists, biologists, pharmacists and a medical unit headed by a physician. The chemists are concerned with new compounds with biological activity which may become new drugs for use as analgesics, local anæsthetics, muscle relaxants and for the treatment of diseases involving nervous and muscular defects. They work in close association with the biologists responsible for testing the new compounds for their potency, absence of side-effects, etc. The pharmacists work on the presentation of drugs to ensure maximum effect and convenience for doctor and patient and on problems of stability and analysis. The medical unit makes arrangements for the clinical trials of new drugs. An extensive library is maintained which acts as an information centre for the research staff and the other technical staff of the Company.

National Science Foundation Co-operative Graduate Fellowships

THE National Science Foundation has announced a new programme of co-operative graduate fellowships under which approximately 1,000 fellowships will be offered to graduate students in the sciences and engineering. To be eligible, candidates must be citizens of the United States and have special aptitude for advanced training and productive scholarship in the sciences. This programme is in addition to the Foundation's regular predoctoral, postdoctoral, senior postdoctoral and science faculty fellowship programmes. In the first experimental year of operation, applicants may apply to study at one of 115 designated colleges and universities. Applications will be forwarded—together with the institution's recommendations—to the National Science Foundation, where they will be considered by panels of scientists appointed by the National Academy of Sciences—National Research Council. Fellows will receive a basic annual stipend of 2,200 dollars with the option of nine or twelve months tenure. Supplemental support may be extended by the institutions themselves to encourage Fellows to undertake limited teaching responsibilities during tenure of their fellowships. In addition, the Foundation will provide each institution, in lieu of tuition fees, with a fixed amount for each co-operative graduate Fellow at that institution. Co-operative graduate fellowships will be offered in the mathematical, physical, medical, biological and engineering sciences, as well as in anthropology, psychology (excluding clinical psychology), and in certain social sciences, including geography, mathematical economics, econometrics, demography, information and communication theory, experimental and quantitative sociology, and the history and philosophy of science.

National Museum of Canada

THE report of the National Museum of Canada for 1955–56 (pp. iii+140 (17 plates). Ottawa: Queen's Printer, 1957. 1.50 dollars) is far more than a formal report on the work of the institution, for it also includes papers on research work undertaken by or in collaboration with the staff. The record of the general activities includes an impressive amount of educational work carried out through the media of exhibits, lectures, publications, photographs, film strips and correspondence. Visits to the Museum by organized groups were also encouraged, and some 4,000 individuals attended the Museum in this way. Each group was provided with a guide. The papers published in this report include such diverse subjects as archæological work on Southampton and Walrus Islands, Tertiary mollusca from Princeton, British Columbia, Paleocene mammal teeth from Alberta and a bibliography of Canadian anthropology for 1955.

Equipment for Archæology and Geology

MESSRS. P. J. DUTT AND CO., LTD., of Alfred Place, Store Street, London, W.C.1, have recently issued a comprehensive and fully illustrated catalogue entitled "Equipment for Archæology and Geology", in which the emphasis is perhaps on geology rather than archæology, though the requirements of archæologists are by means neglected, being often coincident with those of geologists. All branches of geology are catered for, including both field and laboratory work, mineralogy, petrology and palæontology. The soil scientist, too, will find some of the items listed of interest. The instruments and equipment are grouped under the following headings: collecting; mapping and surveying; specimen preparation, display and preservation; laboratory equipment, including microscopes; and teaching aids. The catalogue covers a wide variety of field and laboratory activities, and should prove useful to both amateur and professional geologists, archæologists and museum curators. Messrs. Dutt also point out they are agents for Ward's Natural Science Establishment, New York, and Soiltest Incorporated, Chicago, from whom they are prepared to import specialities not available in the United Kingdom.

Rheology Abstracts

VERY soon after the British Rheologists' Club was started in 1940, its first *Bulletin* appeared, "gratis, to members of the Club only". This contained notices of meetings, news of interest to members and abstracts of recent rheological papers. After the publication of the fifty-third *Bulletin* (December 1957) the sponsors, now called the British Society of Rheology, decided to change the form of publication, the *Abstracts* being issued separately from the *Bulletin*. The latter contains news for members, summaries of papers given at conferences, etc., while the former is now headed "A Survey of World Literature" (1, No. 1; May 1958. Pp. 31. Four issues a year: subscription £2 per volume of four issues. London: Pergamon Press, 1958. Published for the British Society of Rheology).

The organization of such a venture by honorary abstractors alone is no small undertaking. The coverage must depend on chance factors involving the interests of the volunteers. The Society has decided to start with the material available and to expand coverage as opportunities arise. Already, more than a hundred journals are abstracted regularly. The aim is to direct attention to papers in journals which are fairly easily obtained and understood, while giving rather fuller abstracts of worthwhile articles in obscure journals or less-known languages. The classification is under seven headings: theoretical; instruments and techniques; metals and other solids; polymers, elastomers and viscoelastic materials; pastes and suspensions; liquids; general (miscellaneous). It is a pity that attempts made some ten years ago to start an international rheology abstract journal proved abortive. To-day, several of the national societies provide excellent abstract services, a situation which results in much overlapping. Nevertheless, in existing circumstances, the British Society of Rheology had no alternative but to organize its own survey and, until an international service can be organized, the *Abstracts* in their new form should prove very valuable to rheologists both in Britain and abroad.

History of Thermometry

A VERY interesting booklet has been issued by Messrs. Negretti and Zambra entitled "A Story of Temperature Measurement" (pp. 20. London, 1958), in which the history of the thermoscope and the liquid-in-glass thermometer is outlined from the earliest times up to the most modern forms. The earliest forms of thermoscope were devised for medical purposes, and arbitrary 'degrees' of heat and cold (which were both regarded as positive qualities) were called upon to indicate a patient's condition. Measurement began early in the seventeenth century, but it is uncertain to which of three or four inventors the credit for the construction of the first thermometer is to be ascribed. In the earliest instruments, variations in the volume of air enclosed in a bulb were used to indicate changes in temperature, but ignorance concerning the effect of atmospheric pressure vitiated their use for precise scientific purposes. The present-day forms of liquid-in-glass thermometer—the Fahrenheit, Réaumur and Celsius—appeared almost simultaneously early in the eighteenth century, and the circumstances of their invention, which have been widely misrepresented, are accurately described. The account is enriched by a large number of illustrations, many of which show instruments to be seen at the Science Museum, South Kensington, and by a useful bibliography. It can be recommended as a readable and trustworthy summary of an interesting chapter in the history of science.

Royal Australian Chemical Institute: Officers

MR. L. W. WEICKHARDT, technical director of Imperial Chemical Industries, Australia and New Zealand, Ltd., has been elected president of the Royal Australian Chemical Institute for 1958–59, and Mr. W. H. Wainwright has been elected vice-president. The other members of the Council are Mr. W. S. McGowan and Mr. C. I. Cox (New South Wales); Dr. J. M. Harvey and Dr. H. E. Dadswell (Queensland); Mr. R. G. Cooke (South Australia); Mr. J. L. Flounders and Dr. J. A. Allen (Tasmania); Dr. D. R. Zeidler and Dr. A. L. G. Rees (Victoria); Dr. D. E. White and Mr. L. R. Allison (Western Australia); Dr. A. Walkley (honorary general secretary); and Mr. G. Junck (honorary general treasurer).

University News:

Birmingham

THE title of reader in physics has been conferred on Dr. J. H. Fremlin, senior lecturer in physics, and that of reader in comparative neurology on Dr. J. T. Eayrs, senior lecturer in neuro-anatomy and at present Henry Head Research Fellow of the Royal Society in the Department of Anatomy. Approval has been given for the establishment of a chair of organic chemistry within the Department of Chemistry. The following appointments have been made: Dr. G. V. Chester, to be lecturer in mathematical physics; Dr. M. H. Cardew and Dr. M. B. King, to be lecturers in chemical engineering.

Bristol

THE following appointments have been made: Miss Dorothy J. Cooper, to be lecturer in education; and Dr. A. J. Forty, to be lecturer in physics.

The following gifts, among others, have been received by the University: a legacy from Mrs. Hilda Grace Pickard of her residuary estate (subject to three life interests) upon trust to create an endowment fund and to apply the income for the purpose of research into the alleviation of cancer, to be named the Pembery Research Trust—funds totalling £10,084 representing approximately two-fifths of the total residuary estate have now been transferred to the University; £6,300 from the Department of Scientific and Industrial Research to the Department of Physics towards the cost of Prof. C. F. Powell's research on heavy mesons and hyperons by the photographic method; grants totalling £6,086 from the Department of Scientific and Industrial Research to the Department of Physics for salaries and equipment for research work under Prof. Powell; £1,100 from the National Coal Board to the Department of Physical and Inorganic Chemistry for a continuation of the study of reactivity of carbon surfaces with oxygen; and £1,700 from the Department of Scientific and Industrial Research for research assistants and equipment; £1,315 from the Ministry of Supply to the Department of Aeronautical Engineering for research on the prevention of flutter by damping; £1,000 from the Agricultural Research Council to the Department of Veterinary Medicine for research on the nutrition of the baby pig; and £1,000 from the Nuffield Foundation to the Department of Veterinary Anatomy for research on age changes in the vertebral disk of the cat.

London

SIR JOHN ATKINS has been admitted as the first Fellow of Queen Elizabeth College in recognition of his unique service. It is to his vision and determination that the College owes its existence, and he has worked for it continuously since 1911 when, as honorary secretary of the Appeal Committee, he inspired a few generous benefactors to subscribe the funds needed for the erection of the present buildings. He remains a member of the Governing Body, to which he was elected in 1912 and of which he has been chairman since 1922. He is being succeeded as chairman by Sir George Allen, secretary of the British Association.

In the paragraph on 'Commonwealth Fellowships' in *Nature* of November 8, p. 1276, the percentage of overseas students at the Imperial College of Science and Technology, London, was quoted as 38, a figure which has been reported previously in the Press. The Registrar of the College states that this refers only to postgraduate students (full-time and part-time). The percentage of undergraduate students from overseas is only 10 per cent. The total number of full-time overseas students has been rising steadily since the programme of expansion started in 1953, but the proportion has scarcely changed. In 1952–53 there were 312 from overseas out of a total of 1,653 full-time students, or 19 per cent. Last session the corresponding figures were 528 out of 2,437, or 22 per cent. The number this term is 552 out of 2,580, or 21 per cent.

The Night Sky in December

NEW moon occurs on Dec. 10d. 17h. 23m. U.T., and full moon on Dec. 26d. 03h. 54m. The following conjunctions with the Moon take place: Dec. 22d. 05h., Mars 4° N. Mercury rises about two hours before the Sun at the end of the month, but conditions are not favourable for observation. Venus is too close to the Sun for observation. Mars sets at 6h. 05m., 4h. 55m. and 4h. 00m. at the beginning, middle and end of the month, respectively. Mars retrogrades until December 20, after which date it resumes its eastward motion among the stars; it is in Aries throughout December. Its stellar magnitude decreases during the month from $-1\cdot6$ to $-0\cdot6$, its distance from the Earth increasing from 49 to 67 million miles. Jupiter rises at 5h. 50m., 5h. 10m. and 4h. 25m. on December 1, 15 and 31, respectively; it is east of α Libræ. The stellar magnitude of Jupiter is $-1\cdot3$; conditions for observation are not very favourable. Saturn is too close to the Sun for observation. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Dec. 23d. 22h. 33·6m., δ Tau. (*D*); Dec. 23d. 23h. 03·2m., 64 Tau. (*D*); Dec. 28d. 20h. 29·2m., A^1 Cnc. (*R*); Dec. 29d. 04h. 04·0m., α Cnc. (*D*); Dec. 29d. 04h. 59·8m., α Cnc. (*R*). *D* and *R* refer to disappearance and reappearance, respectively. The Geminid meteors are active during December 9–14, conditions being very favourable; the radiant is near R.A. 7h. 28m., Dec. + 32°. The Ursid meteors are active on December 21, but conditions for observation are unfavourable. The winter solstice occurs on Dec. 22d. 09h.

Announcements

ON November 22, H.M. the Queen conferred the Order of Merit on Viscount Samuel. This award is a tribute to a life-time of devoted public service, including fifty years as a Privy Councillor.

DR. VITTORINO VERONESE, a lawyer and formerly president of Catholic Action in Italy, has been elected director-general of the United Nations Educational, Scientific and Cultural Organization for a period of six years.

THE managing trustees of the Drummond Trust will consider, in March 1959, applications for a Drummond Fellowship for research in nutrition. It may be a Senior or Junior Fellowship, depending on the qualifications of the person selected. The value of a Senior Fellowship would be £1,100 per annum with expenses grant and superannuation, and of a Junior Fellowship £500 per annum with expenses grant. The Fellowship will normally be tenable for two years. Full particulars can be obtained from the Honorary Secretary, Drummond Trust, University College London, Gower Street, W.C.1. Completed application forms must be received not later than January 31, 1959.

THE Royal Agricultural Society of England offers annually a medal together with an award of one hundred guineas for research work of outstanding merit carried out in the United Kingdom which has proved, or is likely to prove, of benefit to agriculture. Recommendations for this award can be made by the heads of university departments, research stations and institutes. No direct application by candidates will be considered. Recommendations for the next award must be submitted to the Secretary, Royal Agricultural Society of England, 35 Belgrave Square, London, S.W.1, not later than January 31, 1959, accompanied by nine copies of a brief statement of the candidate's attainments and a list of his publications.

THE fourth Biennial Conference on Carbon, on "The Physics and Chemistry of Carbon Surfaces", will be held at the University of Buffalo during June 15–19, 1959. Information can be obtained from Carbon Conference, University of Buffalo, Buffalo 14, New York.

A MEETING of the Parasitology Group, Institute of Biology, will be held in Edinburgh during March 19–23, 1959. The closing date for registration is February 28. Further particulars of the meeting can be obtained from Miss J. Mahon, Department of Zoology, Bedford College, Regent's Park, London, N.W.1.

THE Institution of Electrical Engineers is holding a Convention on Thermo-Nuclear Processes, during April 29–30, 1959. The probable range of topics is as follows: basic physics of thermonuclear processes; prototype British thermonuclear experiments; constructional features of ZETA 1; design problems of future ZETA-type systems; possibilities of direct conversion from nuclear to electrical energy. Further information can be obtained from the Secretary, Institution of Electrical Engineers, Savoy Place, London, W.C.2.

THE next meeting of the Plant Phenolics Group will be held on January 6, 1959, at the Queen Elizabeth College, London, W.8, under the chairmanship of Prof. R. D. Haworth. The subject will be "Chemistry of Condensed Tannins". Speakers will include Drs. B. Brown, D. E. Hathway, W. E. Hillis, E. A. H. Roberts, D. Roux and T. Swain. Further information can be obtained from the honorary secretary, Dr. T. Swain, Low Temperature Research Station, Downing Street, Cambridge.

UNDER the provisions of the Fulbright Programme, travel grants are available to citizens of the United Kingdom and dependent territories to go to the United States for an academic or educational purpose, provided that they have financial support in dollars for the visit, and have been accepted by an American institution of higher learning. Grants cover the cost of direct travel between a candidate's home and the American university or institution, and are available during June 1, 1959—April 1, 1960. Applications must be submitted by March 14, 1959 (for those travelling between June 1, 1959, and August 15, 1959) or by June 1, 1959 (for those travelling between August 16, 1959, and April 1, 1960). Application forms and further information can be obtained from the United States Educational Commission in the United Kingdom, 71 South Audley Street, London, W.1.

INTERNATIONAL ATOMIC ENERGY AGENCY

THE first annual report of the Board of Governors of the International Atomic Energy Agency to the General Conference* covers the period October 23, 1957–June 30, 1958, in which the membership of the Agency rose from twenty-six to sixty-six. Much of the work of creating the technical and administrative services needed both to implement the initial programme, which allots high priority to activities that will give the maximum benefit from the peaceful application of nuclear energy in improving the conditions and raising the standard of living of people in the under-developed areas, and to co-ordinate the Agency's activities with those of the United Nations and the Specialized Agencies, has been completed and operations commenced in some of the fields assigned by its statute. Excluding posts in the Division of Language Services, some two-thirds of the established posts in the Agency are in the scientific and technical divisions, and in the 111 professional staff appointed by June 30, 1958, twenty-eight nationalities were represented. Deputy directors-general were appointed in December for each of the three technical departments: training and information; technical operations; and research and isotopes. Experience so far has confirmed the Preparatory Commission's expectations that initial activities in regard to the supply of materials, reactors and safeguards would consist largely of planning, collecting and exchanging information, surveys and technical advice.

The major technical assistance activity already operating is the Agency's international training programme, which embraces the training of specialists in all important peaceful applications of nuclear energy by the award of training fellowships and exchanges of scientists and experts. For these fellowships a fund of 250,000 dollars was established, and in addition 268 subsidized or fully paid fellowships for training and research in institutions in their own countries were offered by member States. A field study is being made in Latin American countries to determine their requirements for training in the peaceful uses of nuclear energy and the availability of existing facilities. It is expected that the basic technical library will be functioning by the end of 1958, and the Agency's scientific and technical documentation service is already providing abstracts of scientific material and specialized bibliographies. It is also proposed to issue lists of all conferences in this field held throughout the world and to assist member States and scientific and technical organizations in planning and timing such meetings.

A provisional manual on radiation protection is planned, and an expert panel has been convened, while the collection and evaluation of data on the disposal of radioactive waste have commenced. The reactor programme will be divided into the physics and chemistry of reactors; problems of engineering; and production of nuclear energy. Data are being collected for an international reactor directory covering all types of power, research and training reactors. Under isotopes and research, plans are being made for forming composite isotope teams, including experts on applications of radioisotopes and radiation, to be sent on request to countries in the less-developed areas, and a survey is being made with a view of compiling an international catalogue of radioisotopes. The work of the Agency is further displayed in its Programme and Budget for 1959*, in which an analysis of its proposed expenditure of 6·725 million dollars (including 550,000 dollars on scientific information and conferences, 2·575 million dollars on technical assistance and 1·050000 million dollars on regulatory activities) is accompanied by a description of the functions and programme of each of its departments.

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* First Annual Report of the Board of Governors of the International Atomic Energy Agency to the General Conference covering the period from 23 October 1957 to 30 June 1958. Pp. ii+53. (Vienna: International Atomic Energy Agency, 1958.)

* International Atomic Energy Agency. Programme and Budget for 1959. Pp. vii+94. (Vienna: International Atomic Energy Agency, 1958.)

NETHERLANDS–NORWEGIAN JOINT ESTABLISHMENT FOR NUCLEAR ENERGY RESEARCH

THE sixth annual report* of the Netherlands–Norwegian Joint Establishment for Nuclear Energy Research (J.E.N.E.R.), the joint research and training centre sponsored by the Dutch Reactor Centrum Nederland (R.C.N.) and the Norwegian Institut for Atomenergi (I.F.A.), which has now been published, describes the work of the Establishment during the period July 1, 1956–June 30, 1957. The governing board consists of a joint commission comprising three Dutch and three Norwegian members, and the work of the Establishment is directed by Mr. Gunnar Randers, who was appointed by the Institut for Atomenergi with the approval of the Reactor Centrum Nederland. The staff is grouped into six divisions—physics, engineering, civil engineering, chemistry, isotopes, and health physics—in addition to the administration, and during the period under review totalled 180, of which fifty-four are classified as scientists and engineers and sixty-four as technicians and skilled workers.

The research reactor, JEEP, which is fuelled with natural uranium and moderated and cooled by heavy water and which is situated at Kjeller, was in almost continuous operation at 450 kW. during the year, and approximately 92 MW. days of energy were released. Complete shut-downs occurred only for holidays and for the semi-annual inspection work. The Halden boiling-water reactor (HBWR) which uses heavy water, and which was designed by the Establishment, is being built by the Institut for Atomenergi and is now at an advanced stage of construction; it was expected to go critical some time during 1958. The civil engineering work has been completed; the workshop in the control building has been equipped; and the offices on the first floor of the building are in use. Most of the mechanical components of the reactor are being made by Norwegian firms, but the uranium fuel will be supplied by the United Kingdom Atomic Energy Authority and the heavy water by the United States Atomic Energy Commission. The reactor will be operated at low temperatures to begin with, and preliminary investigations have shown that 2*S*-aluminium withstands these low temperatures well and therefore is suitable as canning material for the initial fuel charge.

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* Sixth Annual Report, July 1956–June 1957, of the Netherlands–Norwegian Joint Establishment for Nuclear Energy Research. Pp. 31. (Kjeller, near Lillestrøm: JENER, 1958.)

Information concerning the probable kinetics of the reactor has been obtained through void-coefficient experiments conducted by the physics division and by the use of a reactor simulator which was built specially for this purpose. The simulator consists of an analogue computer, loaned by the Norwegian Defence Research Establishment, to which has been added various units for the simulation of reactor kinetics and xenon poisoning and a multiplier circuit.

The nuclear ship-propulsion group has concentrated its attention on the use of uranium oxide – light water lattices for ship reactors. Parametric analyses of various fuel-moderator systems have been carried out, and optimization studies of reactor plant components have been made. Problems relating to both normal as well as adverse operational conditions, such as collisions at sea, groundings, fire and explosion hazards, have been considered and discussed with the appropriate Norwegian maritime authorities.

In addition to the void-coefficient experiments the physics division has continued its exponential experiments on heavy water – natural uranium lattices which it is carrying out in co-operation with A. B. Atomenergi at Stockholm. A report of measurements on clean lattices has been published (*J. Nuclear Engineering*, 3; 1956) and a report on cluster type rods has been issued by A. B. Atomenergi (AEF–65). A Nonius general-purpose camera has been added to the X-ray equipment and X-ray work has been mainly concentrated on phosphoric acid. The investigation of capture gamma circular polarization has continued and work on the gamma-spectrum of fission has been started. The health physics service of the Establishment was intensified during the period under review and the report mentions that only one member of the staff received a dose in excess of 5r. and that 81 per cent received less than 1r. The service controls about 150 persons.

Details are also given in the annual report of the production and shipments of radioisotopes; of the activities of the chemistry and metallurgical sections of the Establishment; of the reports and publications published by the Establishment and members of the staff; of the Establishment's reactor courses and of the new reactor school being opened in 1958 with a nine-week full-time postgraduate course in fundamentals of nuclear engineering; and of the personnel and accounts of the Establishment.

RESEARCH AND DEVELOPMENT IN THE B.B.C.

APART from the maintenance and steady improvement of a nation-wide sound and television service, the manner in which the Engineering Division of the B.B.C., and particularly of its Research and Designs Departments, continues to make technical progress, is well illustrated by the B.B.C. Engineering Division Monographs, of which Nos. 15–19 have been published during the past few months* (reference was made to Nos. 12–14 in *Nature*, 181, 1046; 1958). These deal with a variety of subjects, from the quantitative measuring technique which is a necessary tool in the transmission and reproduction of high-quality sound to an appraisal of the results of the experiments made by the B.B.C. in colour television.

Monograph No. 15, entitled "New Equipment and Methods for the Evaluation of the Performance of Lenses for Television", outlines the photo-electric method of testing lenses and describes a new optical bench developed for the purpose. The factors affecting the quality of a television picture are discussed, and formulæ are developed on an experimental basis for an index of quality for both monochrome and colour television.

The analysis and measurement of the extremes of sound programme-levels are dealt with in Monograph No. 16 in two parts: (1) "Investigation of Extreme Values of Sound Pressure", by D. E. L. Shorter and W. I. Manson; and (2) "A Description of an Optical Instrument for Monitoring Sound Signals", by E. R. Wigan. An optical projection type of instrument has been developed, the range of indication of which is sufficient to deal with the most difficult programme material. While the instrument has a limited field of application to sound broadcasting, it has obvious advantages for the control of sound channels in television.

"The Design of a Linear Phase-Shift Low-Pass Filter", by L. E. Weaver (Monograph No. 17), describes the theoretical and practical details of the design of a very linear phase-shift low-pass filter intended to remove noise and other irrelevant information above approximately 3 Mc./s. from the output of a television camera control unit. A "Note on Random Fluctuation Noise in Image Orthicon Camera Tubes", by R. D. A. Maurice, is appended and revises some of the conclusions in an earlier monograph on the distribution of noise over the grey scale of a picture.

Monograph No. 18 forms an interesting highlight in the series under review and is entitled "The B.B.C. Colour Television Tests: an Appraisal of Results", by W. N. Sproson, S. N. Watson and M. Campbell. This describes the results of field trials conducted during 1955–57 in viewers' homes by the Research and Designs Departments of the Corporation after preliminary experiments and the development of suitable receivers in the laboratory. Since the tests were completed, a further series was carried out during 1957–58 and the results are now being analysed.

* B.B.C. Engineering Monographs. No. 15: New Equipment and Methods for the Evaluation of the Performances of Lenses for Television. By W. N. Sproson. Pp. 16. No. 16: Analysis and Measurement of Programme Levels. Part 1: Investigation of Extreme Values of Sound Pressure. By D. E. L. Shorter and W. I. Manson. Part 2: A Description of an Optical Instrument for Monitoring Sound Signals. By E. R. Wigan. Pp. 31. No. 17: The Design of a Linear Phase-Shift Low-Pass Filter. By L. E. Weaver. Pp. 23. No. 18: The B.B.C. Colour Television Tests—an Appraisal of Results. By W. N. Sproson, S. N. Watson and M. Campbell. Pp. 39. No. 19: A V.H.F. Television Link for Outside Broadcasts. By K. C. Quinton. Pp. 20. (London: British Broadcasting Corporation, 1957 and 1958.) 5*s*. each.

The field trials on which the B.B.C. now reports extended over a total period of seventeen months and involved the analysis of more than a thousand questionnaires, filled in by members of the B.B.C. staff and others who watched the results on special sets. So far as reception of the colour picture is concerned, the B.B.C.'s verdict is that the colour pictures produced by the N.T.S.C. system as adapted to 405 lines, with the picture sources and display tubes that are at present available, are satisfactory. The problem of registration with the three-tube colour camera requires attention, and certain features of the display tube could with advantage be improved, but the technical performance of the system is adequate for a satisfactory colour television service in the frequency bands at present in use. The tests radiated from Crystal Palace during November 1956–April 1957 included live studio performances, film and slides. Of the observers, 89 per cent regarded the reception of the live scenes as satisfactory. The 35-mm. film was regarded as satisfactory by 100 per cent of the observers, the 16-mm. film by 93 per cent, and the slides by 98 per cent. The compatibility of the transmissions was very good indeed. This means that the quality of ordinary black and white television, when received on a colour television set, was found to be generally satisfactory; and likewise the quality of the colour transmissions, when received in black and white on ordinary television sets, was completely acceptable to 94 per cent of technical observers.

The results of the tests have been communicated to the Television Advisory Committee, which has the task of advising the Postmaster-General on the whole field of television. The results have also been sent to the International Radio Consultative Committee which recently met in Moscow to consider colour television. The B.B.C. will carry out further experimental transmissions from time to time. It is pointed out that there are many other problems to be solved: for example, the production of a reasonably priced colour-receiving set and agreement on the future standards to be applied to the development of television in the United Kingdom. The decision whether or not there is to be a public service of colour television, and if so the system to be used, rests with the Postmaster-General.

A national television network requires to be adequately supported by inter-connecting line and radio links capable of transmitting without distortion the complex signals conveying the sound and vision information. Where outside broadcasts are concerned, mobile equipment is usually necessary, and the design and development of such equipment is described in Monograph No. 19, by K. C. Quinton, under the title "A V.H.F. Television Link for Outside Broadcasts". This provides, first, a brief historical introduction to the problems of radio linkage. leading to the need for using ultra-high frequencies, with particular reference to moving-camera applications and to propagation over water. The relative merits of amplitude and frequency modulation are explored in theory and practice; and details are given of the equipment developed for use in the frequency-range 610–660 Mc./s. The first year's operational experience with such equipment has been very successful.

ROAD RESEARCH

THE work of the Road Research Laboratory is concerned partly with the behaviour of traffic on the road, and partly with the performance of materials and with the methods of construction of the road itself. The Laboratory's annual report for 1957* is interesting and well presented.

Some problems of traffic and safety can be solved by a controlled experiment. For example, the Laboratory conducted a full-scale experiment with streams of traffic weaving through each other as the vehicles entered and left a roundabout. This led to an empirical formula, from which the limiting traffic flow could be predicted accurately. The Laboratory has also developed an apparatus for measuring accurately the resistance of a road surface to skidding; one graph shows a seasonal variation of this resistance which corresponds closely with the seasonal variations in the number of skidding accidents.

To study other problems, the Laboratory conducts various field surveys. For example, a survey of the flow of traffic in the streets of London and Glasgow showed an average journey-speed of ten miles per hour with vehicles stopped for about a third of their journey time. Detailed field studies of accidents suggest that the doors of British cars tend to jam in a crash, while the doors of American cars tend to fly open. Their conclusion from a study of reports of a sample of fatal accidents was that 13 or 14 per cent of fatal accidents involved a person who had drunk alcohol (the official statistics suggest a figure of only 2 per cent), and showed further that, "one half of the drivers and more than one half of the pedestrians involved in fatal accidents at night had been drinking".

Experiments to reduce accidents have sometimes been very successful: a big roundabout can eliminate three-quarters, and a smaller roundabout a half, of the accidents at an intersection. Sometimes success is more elusive. A full-scale attempt to reduce road casualties in Slough over a two-year period produced only an "apparent reduction" compared with the increasing numbers of casualties in Great Britain as a whole, which must have been something of a disappointment. Perhaps it was a mistake for the Laboratory to be too much concerned with traffic conditions in a town so close at hand.

In the work on materials and methods of construction a major experimental section of road has been constructed as part of the new north-bound carriageway of the Great North Road at Alconbury Hill in Huntingdonshire: there are seventy different variations in the pavement construction within a length of 2¼ miles, although the passing motorist is probably only aware of the changes at one or two points in this length. This experiment is concerned with fairly conventional pavement construction, but it is interesting to read of the continued satisfactory performance of some other experiments of previous years when lengths of cement-stabilized gravel base were constructed. Such a base is inherently cheaper and quicker to construct than a normal base; perhaps British engineers in the past have concentrated too much on the stabilization of the soil that happens to be on the site, and have given insufficient attention to the possibility of stabilizing low-grade unwashed gravel which may be available close by. Work on concrete and bituminous materials is also described.

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* Department of Scientific and Industrial Research. Road Research 1957: The Report of the Road Research Board with the Report of the Director of Road Research. Pp. iv+93+8 plates. (London: H.M. Stationery Office, 1958.) 5s. 6d. net.

The report begins with an attempt to gauge the importance of the road problem in Britain. The cost of road accidents is about £100 million a year, and that of time and fuel wasted in congested traffic is several times that figure. The present programme of road improvements is based on information that appears to be inadequate as a basis for design, and in comparison with the sums of money that have been mentioned above the expenditure on road research is negligible. The civil engineering industry itself does relatively little research, and the paucity of the support which the work of the Road Research Laboratory receives can be gauged from a disturbing sentence on the Alconbury Hill experimental section which ". . . was planned some twelve years ago" but was only constructed last year. This is a straightforward experiment for which a site should have been found so that the work could be carried out well in advance of the present road-construction programme. It must be hard to continue with research that apparently receives slight encouragement, and know that for lack of design data the new roads that are now being built are probably not so good as they could be.

A. N. SCHOFIELD

JANE COFFIN CHILDS MEMORIAL FUND FOR MEDICAL RESEARCH

THE Jane Coffin Childs Memorial Fund for Medical Research, of New Haven, Connecticut, made appropriations totalling 312,779·93 dollars in support of research and fellowships in cancer for the year July 1, 1957–June 30, 1958. This brought to slightly more than four million dollars the total distributed by the Fund since its establishment in 1937.

Support is given by the Fund to research in both the basic and clinical sciences; for postdoctoral fellowships providing opportunity for advanced training and research; and for conferences and meetings of national and international societies concerned with cancer research. Among publications to the support of which the Fund has contributed since it helped to establish them are the journal, *Cancer Research*, and the "Atlas of Tumor Pathology".

Applications for research grants and fellowships are reviewed by the Board of Scientific Advisers, directed by Dr. M. C. Winternitz, three times a year at the offices of the Jane Coffin Childs Memorial Fund for Medical Research, 333 Cedar Street, New Haven 11, Connecticut.

Although most of the Fund's grants are given to American investigators, no geographical restrictions are placed on its allocations. Austria, Britain, France, Japan and Sweden are represented on the current list of grants for 1958. Dr. Bengt E. G. V. Sylvén, associate professor of experimental cancer research in the Karolinska Institute at Stockholm, received a first grant (30,000 dollars for three years) for development of cytochemical methods to be used in attacking a long-standing controversial question in cancer—the relation of proteolytic enzymes in the malignant cell to the penetration of surrounding tissues by cancer. Dr. Jacques Monod, director of the Department of Cellular Biochemistry at the Pasteur Institute, Paris, received a fifth grant (totalling 29,400 dollars since 1954) for studies of specific enzymes involved in the selective penetration of certain organic molecules into bacterial cells. Grants made to the Institute of Cancer Research, Royal Cancer Hospital, London, beginning in 1938 when the late Sir Ernest Kennaway, then director of the Institute, visited the Fund in New Haven, now total 73,500 dollars. American investigators supported by the Fund in 1958 were working chiefly in university and medical school departments of the basic and clinical sciences, ranging from genetics and botany to surgery and medicine.

Among the long-term programmes at present supported by the five-year grants is that of Dr. Charles B. Huggins and his associates (25,000 dollars a year) at the Ben May Laboratory of Cancer Research, University of Chicago.

In accordance with the developing trend in most of the research on cancer, biochemical approaches outnumber all others in the work of both investigators and Fellows supported by the Fund, with especial concern for the chemical reactions in normal and neoplastic cells and tissues and with particular interest in protein and nucleoprotein metabolism. These and other chemical approaches to the problems of cancer were being studied in tumour and other viruses, in immunological mechanisms, in connexion with the steroid hormones.

Among other grants made by the Fund for the first time in 1958 are those to Dr. L. L. Engel (Massachusetts General Hospital) for work on methods for studying urinary steroid metabolites in cancer; to Dr. E. H. Stotz (University of Rochester) to investigate the occurrence and role of peroxidase in proliferating tissue and its response to hormones; to Drs. R. W. McKee and H. Cook (University of California) for work on physico-chemical and biological characterization of nucleic acids and proteins from several different ascites tumours; to Prof. J. N. Davidson (University of Glasgow) to investigate nucleic acid metabolism in cancer tissue; to Dr. Osamu Hayaishi (Kyoto University) for work on the biological synthesis and degradation of peptides and proteins; and to Dr. Stanfield Rogers (University of Tennessee) to investigate the mechanism of action of the Shope papilloma virus in producing papillomas in rabbit epithelium.

New Fellows supported by the Fund in 1958 include Dr. P. Ottolenghi (Copenhagen), Dr. G. L. Hagen (Harvard), Dr. M. Richter (Indiana), Dr. L. Del Gatto (California), Dr. E. V. W. Yamada (U.S. National Institute of Arthritis and Metabolic Diseases), Dr. K. R. Hanson (New York), Dr. Monto Ho (Harvard), Dr. D. Rubinstein (Michael Reese Hospital, Chicago), Dr. A. Iodice (University of California, Berkeley), Dr. E. A. Carusi (California Institute of Technology), Dr. J. Rothschild (Rockefeller Institute for Medical Research), Dr. J. B. Mudd (University of California, Berkeley).

GULBENKIAN FOUNDATION, LISBON

GRANTS FOR 1958

THE Trustees of the Calouste Gulbenkian Foundation, Lisbon, have announced a list of grants made during 1958 and amounting in total to nearly £1 million. The two previous lists of grants, issued in April and November 1957, totalled £1½ million. Out of this year's grants the British Isles and the Commonwealth overseas receive more than £200,000.

The list of grants includes: £42,000 to the Old Bodleian Library, Oxford, for restoring the fabric of this building, begun in the fifteenth and completed in the seventeenth century; £30,000 to Fort Jesus, Mombasa, for the restoration of the sixteenth century Portuguese fort and its conversion into a museum of East African history and archæology under the care of the Royal National Parks of Kenya; up to £6,000 over three years to the International Institute for the Conservation of Museum Objects; £1,500 to the Welsh Folk Museum for recording equipment for a survey of Welsh oral traditions of the countryside, including the domestic, agricultural and craft vocabularies, before they disappear under the impact of modern technology; £32,500 to the Centre for Nuclear Energy Research, Portugal, for equipment, and running costs for three years, for its mass spectrometry and isotope section; to the University of Coimbra, (*a*) the Chemical Laboratory, £12,430 for a spectrophotometer and expensive books, (*b*) the Physics Laboratory, £6,200 for analyser and other equipment for atomic energy research, (*c*) the Galenic School of Pharmacy, £3,020 for apparatus for electrophoresis and chromatography, (*d*) the Institute of Geophysics, £1,750 for scientific equipment; £14,375 to the Bento da Rocha Cabral Institute for Scientific Research for equipment and three years research expenses; £12,850 to the Centre for Research in Infectious Diseases, Portugal, for capital and running costs for three years; £11,250 to the Centre for Economics and Statistical Research, Portugal, over three years, for seminars and training of future research workers; £4,170 to the National Agronomy Station, Portugal, for books for the library; £3,750 to the Egas Moniz Research Centre, St. Mary's Hospital, Lisbon, for fellowships; £2,000 to the University of Lisbon Botanical Garden and Laboratory, for microfilm reader, microscopes and transport for field-work; £1,250 to the Organic Chemistry Laboratory, Higher Technical Institute, Lisbon, for equipment; £1,080 to the Hospital of Dona Estaphania, Lisbon, for scientific meetings organized by the head of the Department of Child Health.

Scholarships and other grants for education or study at home or overseas for the year 1958–59 include: £112,500 for Portuguese students and scholars, £20,000 for Armenian students, and £10,000 for scholars, research workers, etc., and £15,000 for Middle East students. In the United Kingdom £4,030 was spent in 1958.

Other grants include £50,000 to Churchill College, Cambridge, to endow three Gulbenkian studentships for graduates of universities outside the United Kingdom; up to £3,750 to the Institute of Archæology, University of Coimbra, and other archæological bodies; £3,000 to the Department of Education, Oxford, directed by Mr. Alec Peterson, to enable a study to be made of specialization in schools and its real relevance to university requirements, and then to attempt to draft an ideal syllabus and timetable for a combined arts and science sixth form; £350 a year for three years to the Egypt Exploration Society and Ashmolean Museum, Oxford, for a technician to be trained (by the reader in papyrology in the University of Oxford) in the technique of piecing together fragments of ancient papyri by matching the fibres instead of the text; £600 over two years to Prof. Christopher Hawkes (University of Oxford) for visits to Portugal at the invitation of the Ministry of National Education to collaborate with Col. Mario Cardoza of Guimarães in the excavation of early Celtic *castros* and in the training of Portuguese archæologists in the latest techniques of excavation; £700 to the Department of Economics, University of Bristol, for a study of the 'employability' of workers who have suffered long-term unemployment due to ill-health. Out of funds set aside in 1957, the Foundation has assisted one undergraduate scientific expedition this year, namely, the Westminster Hospital Medical School's expedition to the Belgian Congo. In addition, the Royal Geographical Society, London (which already lends surveying instruments to expeditions), has accepted £1,200 for a pool of other instruments and equipment for loan to university expeditions.

BIOCHEMICAL RESPONSE TO PHYSICAL INJURY

A SYMPOSIUM on "The Biochemical Response to Physical Injury" was held at Semmering, Austria, during September 7–12 under the ægis of the Council for the Organization of Medical Sciences with the assistance of the Wellcome Trust and the International Union of Biochemistry. Radiation injury was excluded from discussion.

Dr. D. P. Cuthbertson (Scotland) acted as chairman and Dr. H. B. Stoner (England) was technical secretary. The general and local arrangements were respectively in the hands of Dr. J. F. Delafresnaye (Council for the Organization of Medical Sciences) and Dr. F. G. Wewalka (Austria).

F. A. Fuhrman (United States) opened with a description of "Electrolytes and glycogen in injured tissues". He pointed out that we know more about the electrolyte pattern and its control in skin and skeletal muscle—which constitute 70 per cent of the mass of the soft tissues of the body and which are more frequently injured than other tissues—than in any other. The main difficulty, however, is our inability to determine precisely the size of the extracellular space in injured tissue. The replacement of intracellular potassium by sodium following injury is of very great interest and appears to be due to failure of the sodium pump rather than to death of cells. It is not known how long intracellular sodium must be present to be harmful; or, indeed, whether it ever does become harmful. At least eight different enzymes are activated by potassium and inhibited by sodium. Abnormal carbohydrate tolerance has been demonstrated in potassium-deficient animals in which part of the intracellular potassium was replaced by sodium. But much more information is necessary before the electrolyte changes in complex injuries can be causally related to alterations in physiological function.

J. Trémolières and R. Derache (France), in "Metabolism of nucleotides and phosphate in injured tissue", described the uniformity of the local response to injury as exemplified by the fact that the changes in the acid-soluble phosphorus compounds go on in nearly identical ways whatever the injury (radiation excepted). There is a reduction of energy-rich compounds (phosphocreatine and adenosine triphosphate) as in anaerobic conditions. Beyond a certain point cellular lesions become irreversible. These investigators then described the state in anoxic ischæmia and of revascularization. They suggest that local œdema can be explained by a fall in the protein - adenosine triphosphate complexes which are able to select between potassium and sodium. Necrosis and irreversible proteolysis can be related to the structural functions of adenosine triphosphate in mitochondria and proteins.

"The endogenous substances inducing pathological increases in capillary permeability" were considered in two papers by A. A. Miles and D. L. Wilhelm (England), who discussed the activation of endogenous substances increasing capillary permeability (Miles), and the evaluation of the role of endogenous permeability (Wilhelm). They emphasized that among the early responses to injury, the inflammatory reaction is paramount. In their view, in our present state of knowledge it is almost impossible to analyse the factors operative in a long-lasting and severe inflammation, and progress in this field is most likely to be achieved by studying the essential reactions of inflammation induced by minimal stimuli. Judging from the large number of relatively simple substances which can increase permeability, it is possible that the tissues use one or several of a variety of endogenous substances as mediators, and that these differ according to the type of injury. In certain circumstances and certain animals, histamine and 5-hydroxytryptamine appear to be mediators. These workers could not subscribe to the view that, since endogenous leukotaxine, globulin permeability factor and so forth are there, they must in consequence play some part in permeability changes, otherwise they would not be there. Their view is that even supposing all endogenous substances in the body have their proper and necessary role in the living tissues, the biological activities in terms of which we choose to identify and explore them may be wholly irrelevant to the function they fulfil in the body.

A. Fonnesu (Italy) described "Changes in energy transformations as an early response of the cell to injury". The well-known histological picture of cloudy swelling is the morphological result of these changes—a condition described by Rudolph Virchow in 1871 as a kind of acute hypertrophy with tendency to degeneration. The features of this condition are as follows: (1) an alteration of the mitochondria which follows, or is followed by, a partial inhibition of phosphorylation coupled with oxidation; as a consequence, aerobic glycolysis increases; (2) increased protein synthesis. Assuming the mitochondrial alteration is the first response of the cell to injury, this may be the cause of an increase of aerobic glycolysis and an increase of inhibition. No answer can be given as to how impairment of oxidative phosphorylation can lead to an enhancement of an endoergonic process such as protein synthesis. Other conditions, in pathology, are known in which the uncoupling of oxidative phosphorylation is accompanied by an increase of both glycolysis and protein synthesis.

Concerning the more general response to injury, "The effect of limb ischæmia on carbohydrate distribution and energy transformation" was analysed by H. B. Stoner and C. J. Threlfall (England). It appears that during the period of limb ischæmia and for the first part of the survival period afterwards, the brain, liver, heart and uninjured muscle are adequately oxygenated and the metabolic changes in these organs cannot be attributed to hypoxia. The secretion of the adrenal medulla in response to the injury is the main cause of the altered carbohydrate distribution. The mechanism of the changes in energy transformations which occur at this time is not yet understood.

In the estimation of these investigators the ability of the animal to withstand the injury is probably decided during this early period and it is possible that the biochemical changes which occur are part of a defensive mechanism. If the animal is unable to withstand the injury, oxygen transport fails during the later part of the survival period and the resulting tissue hypoxia leads to the terminal changes in energy (heat) production and carbohydrate metabolism.

A. G. B. Kovách (Hungary), in a paper on "Metabolic responses to injury in the cerebral tissues", described the favourable effect of perfusion of the brain with normal blood in hæmorrhagic and ischæmic shock. The functional changes as tested by electrocorticographic investigations support the hypothesis that impairment of the nervous system plays an important part in the development of shock. The oxygen consumption of the brain—its oxygen requirement—does not decrease during shock, in fact it rises, in spite of the fact that the circulation in the head is deficient. Unlike muscle where the glucose uptake is lessened after shock, the brain remains unchanged in this respect, to the terminal stage, when it diminishes. The hexokinase activity in the brain of the animal in shock increases, whereas in muscle it is slowed up. On the other hand, cerebral anoxia (stagnant or arterial) lowers the brain hexokinase activity. These and other changes—particularly in phosphorus compounds—might be attributable to an increase in intracellular potassium ions. The mechanism of this can only be determined by further experiment.

R. Fåhraeus (Sweden) described the "Tissue injury due to the reduced filtrability of the erythrocytes". The intravascular aggregation of the erythrocytes in rouleau formation (termed by Knisely 'sludging') implies a mechanism which is advantageous for the circulation of the blood in certain aspects of the vascular system. This aggregation of the erythrocytes favours their transport at the expense of the plasma and decreases the relative viscosity of the blood. But such rouleau formation may give rise to circulatory disturbance.

Determination of the filtrability of the erythrocytes at different blood pressures indicates that a large fall in blood pressure must have a more serious prognosis when the suspension of the blood is strongly reduced. In clinical cases with great aggregation of the erythrocytes the circulation *sub finem vitae* ceases earlier.

In reviewing the "Effect of physical injury on lipid metabolism", E. J. Masoro (United States) dealt mainly with the effects of cold injury and the interrelationship of energy generation and the intermediary metabolism of lipids. At the moment the greatest barrier to the understanding of the effect of physical injury on lipid metabolism is still the absence of certain key data.

D. P. Cuthbertson (Scotland) contributed by discussing "The disturbance of protein metabolism following physical injury". He pointed out that the increased metabolism and urinary excretion of nitrogen, sulphur, phosphorus, potassium and creatine are the main energy and material losses to the body following moderate to severe physical injury such as the fracture of a femur. These alterations in catabolism reach their peak about the third to eighth day in man. There is also generally a slight rise in body temperature and pulse-rate. Comparable changes in nitrogen metabolism are found in the rat, sheep and, as Needham has shown, even in Crustacea. This rise in the surviving organism succeeds an initial depression of vitality following receipt of the wound. In the animal depleted in protein there is no increase in protein catabolism and in heat production following injury. The degree of response is related to the previous nutritive state.

Injury to an animal leads to lessened activity and lessened activity usually results in a diminished food and water intake. The necessity to heal is urgent and Dr. Cuthbertson's view is that the injury done sets in motion a chain of events to meet both the exigencies of repair and of maintenance. This involves changes which may even affect the internal milieu. The rise in heat production which is traceable to the protein oxidized will undoubtedly affect the rates of biochemical reaction.

A. Pekkarinen (Finland) gave a well-documented account of "The effect of operation and physical injury on the adrenal glands and the vegetative nervous system in man". The excretion of adrenaline, noradrenaline and total 17-hydroxycorticosteroids increases markedly after certain operations, thus showing a close relation between the vegetative nervous system and the pituitary-adrenocortical system, at least functionally. The rises might be regarded as of therapeutic benefit, promoting the adaptation of the organism to the stress of operation. The highest urinary excretions of noradrenaline and adrenaline correspond to liberation of 5 mgm. noradrenaline and 8·4 mgm. adrenaline. In most patients the excretion of these substances becomes normal during the first three days after operation. It may also be assumed that the secretion of steroids by the suprarenal cortex may decrease owing to the increased circulatory 17-hydroxycorticosteroid inhibiting the secretion of adrenocorticotrophic hormones from the pituitary gland.

An interesting finding is the significantly higher excretion following injury of adrenaline, noradrenaline and total 17-hydroxycorticosteroids in men compared with women.

The part played by aldosterone secreted by the adrenal cortex in the regulation of the humoral equilibrium during operations is yet unknown.

"Fluid, electrolyte, and plasma protein disturbance in shock" were dealt with by R. C. Millican (United States). He pointed out that this kind of study is important, for circulatory collapse occurs in normal animals in which there are losses of fluid, electrolyte, and protein to the extent observed in shock arising from hæmorrhage or swelling at the site of physical injury. Under certain conditions death from shock can be prevented by administration of fluids, electrolytes, and proteins. In untreated shock associated with a swelling of the injured areas of about 4–5 per cent of body weight, the fluid accumulation within the injured area occurs at the expense of the injured tissues.

The total sodium accumulation in the injured area of mice following application of a tourniquet to the hind legs is equivalent to the entire sodium in the circulating blood, or approximately 25 per cent of the extracellular fluid.

Dr. Millican considered that as substantial amounts of potassium were liberated from injured tissues this was an important factor in shock when combined with the fluid and sodium loss. Doubt is cast on the importance of plasma protein in shock in mice by the lack of effectiveness of protein solutions when administered in the absence of electrolytes. Survival response is closely related to the sodium content of the administered fluid.

V. Wynn (England) took up one aspect of the clinical side in his paper on "Some problems of water metabolism following surgery". He considers that the common finding of a low plasma osmolarity for several days after the trauma is explained by water retention in excess of electrolytes. Since renal function may be otherwise normal, present evidence suggests persistent antidiuretic hormone secretion as the cause of the oliguria. It seems that the supraoptic-hypophyseal system is made more sensitive in some way by trauma, so that a variety of stimuli provoke secretion of antidiuretic hormone ; and the primary function of osmo-regulation by the system is seriously impeded or lost. An inhibitory effect upon aldosterone production is a secondary consequence of the water retention. This leads to renal loss and aggravates the hypotonicity of the body fluids.

In a discussion on the "Influence of environment on the metabolic response to injury" R. E. Haist (Canada) described his experiments, which indicate a prolongation of the survival time of rats, previously exposed to cold, and shocked by a clamping technique, over controls not so exposed. An increased blood volume due to the exposure may also be a factor. Sodium is retained by such cold-acclimatized animals. Previous cold-acclimatization does not alter the changes in muscle chemistry and temperature during and following ischæmia, or the hepatic blood flow after ischæmia, but does lead to a lesser hepatic temperature.

It was clear from H. Smith's (England) account of the "Biochemical response to bacterial injury" that infection with a number of bacteria and injection of different bacterial products can lead to a response in the host physiologically and biochemically similar to that produced by physical injury. The stimulus to this response appears to be a loss of circulating blood volume either from extravasation into tissue spaces locally or generally, for example, in shock produced by anthrax, or from a peripheral pooling of the blood and a decrease in venous return as, for example, in shock produced by staphylococcal and meningococcal toxins. The possible biochemical mechanisms whereby different bacterial products affect blood vessels is a relatively untouched field for research.

W. W. Spink (United States), in his paper on "Brucellosis as a model for metabolic studies on bacterial shock and inflammation," directed attention to the increasing interest shown in recent years in the peripheral vascular collapse caused by endotoxins of Gram-negative bacteria. There is vasoconstriction of the small vessels, which causes ischæmia of the tissues, and changes in cellular function result. This is followed by vasodilation and stagnation of blood, increased vascular permeability, and œdema and hæmorrhage. There is reduced cardiac output because of peripheral pooling of blood. Renal failure occurs because of the compensatory vasoconstriction, which results in ischæmic tubular necrosis.

The metabolic response of the host to bacterial invasion includes alterations in hormonal activity. The adrenal cortex is stimulated, as reflected by increased concentrations of adrenocorticoids, especially cortisone. The thyroid stimulates the activity of the adrenal cortex. Some doubt was expressed as to the wisdom of giving the large amounts of exogenous corticosteroids advised by Dr. Spink during the initial critical period of endotoxin shock. It was of interest that he had found that triiodothyronine accelerated the lethal action of endotoxin.

"The bacterial factor in traumatic shock" was discussed by J. Fine, E. D. Frank, H. A. Ravin, S. H. Rutenburg and F. B. Schweinburg (United States), who found evidence of a toxin appearing in the blood of animals in hæmorrhagic shock, such toxin having many of the hallmarks of a bacterial endotoxin. They consider that it is the cause of the irreversibility to transfusion in their standardized preparations. A toxin with similar properties to the one in the blood in hæmorrhagic shock is apparently present in the blood of the animal in tourniquet shock and in non-bacteræmic septic shock. The source of this toxin appears to be such Gram-negative bacteria as may be present in the animal's tissues, and the endotoxins normally present in the gastro-intestinal tract, which appear to enter the circulation at a steady rate, if only in trace quantities. It is thought that when shock, however produced, becomes unresponsive to therapy, the refractory state of the peripheral vessels is due to unneutralized endotoxins through impairment of the reticulo-endothelial system. The protective effect of reserpine and of dibenamine given prophylactically lend strength to the view that the endotoxins act adversely on these vessels by intensifying the local action of adrenaline or noradrenaline.

S. M. Rosenthal and H. Tabor (United States), in their paper on "Some aspects of therapy of injury", described the survival effects of administering isotonic sodium salts to mice subjected to what would otherwise be one lethal dose of burn trauma, tourniquet trauma or hæmorrhage. In their estimation, sodium and fluid depletion are the major factors in the cause of shock. Saline or plasma in amounts of 5 per cent of body-weight (50 ml./kgm.) is inadequate. These authors have been able to demonstrate a specific effect from the sodium ion in shock. Potassium salts behave in an opposite manner to sodium and are quite toxic. In shocked mice there is an eightfold increase over the toxicity in normal. Glucose and colloid solutions containing no sodium were relatively ineffective in the therapy of shock. The concept that plasma proteins exert their osmotic effects by being held rigidly in the vascular bed must be modified by the demonstration of Wasserman and Mayerson in 1952 that a complete extravascular circulation of the plasma proteins occurs every 20 hours.

In hæmorrhage and hæmorrhagic shock where there is a large loss of red cells, the striking efficacy of administering red cells has been clearly demonstrated, but there is little evidence to substantiate its value in shock from burn or other local trauma. In experimental burns and tourniquet shock whole blood is no more effective than plasma or saline solutions.

In studies on burned children in Peru a small but statistically significant benefit from plasma above that from saline was observed. The important problem of late deaths following severe burns is also being studied in Peru by Drs. Rosenthal and Millican.

This, the first main symposium covering this field of investigation to be held in Europe since the Second World War, was of great value to the participants. The papers contributed and the discussion which followed will be published in due course by Blackwell Scientific Publications, Ltd.

D. P. CUTHBERTSON

FREE RADICAL STABILIZATION

FREE radical chemistry began with the discovery of the stable aromatic free radicals by Gomberg in 1900. The second stage of the subject developed more gradually as the occurrence and importance of unstable free radicals became increasingly apparent and as kinetic and spectroscopic methods for their study in the gas phase and in solution were perfected. During the past few years a third chapter in free radical chemistry has been opened with the realization that even the most reactive of radicals can readily be stabilized for indefinite periods by trapping them in a rigid matrix at low temperatures.

An informal discussion of the Faraday Society on this subject was held in the Chemistry Department of the University of Sheffield on September 4 and 5. The meeting was attended by about one hundred and eighty scientists, half of whom were from Britain, fifty from the United States and Canada, and forty from other countries. Twenty-one papers, covering nearly all aspects of the subject, were presented and discussed.

The three principal methods of preparation of stabilized radicals are: (1) by irradiation of a rigid solid or solution at low temperatures; (2) by electrical or thermal dissociation of a gas and subsequent trapping on a cold surface; (3) by chemical reaction in a rigid or viscous medium, for example, polymerization.

The trapped radicals are then investigated by physical methods, the most useful being absorption spectroscopy in the infra-red, visible or ultra-violet regions, thermal analysis and electron paramagnetic resonance spectroscopy. The latter method is particularly appropriate, and it is fortunate that it was developed at about the same time as methods for the stabilization of radicals.

Practically every type of radical has now been stabilized by one of these methods, from atoms and diatomic radicals to complex odd-electron molecules in polymeric and biological systems. Although the subject is at an early stage of development, the identification of many of these radicals is now quite certain. The simplest of all—the hydrogen atom—is readily prepared and identified by means of its characteristic electron spin resonance doublet, and detailed studies of its formation by gamma irradiation of acid solutions at 77° K. were reported by R. Livingston, H. Zeldes, A. Weinberger and R. Holmberg (Oak Ridge National Laboratory). The isolation of other atomic species is less well established. Unstable products are undoubtedly present in the condensed products of an electrical discharge through nitrogen or after γ-irradiation or electron bombardment of the solid at 4° K. (E. M. Hörl, National Bureau of Standards, Washington), but the evidence at present suggests that, although nitrogen atoms have been detected, N_3 may be the main constituent under some conditions (L. A. Wall, D. W. Brown and R. E. Florin, National Bureau of Standards; also K. Jen, Johns Hopkins University, Maryland).

The first work on the stabilization of simple inorganic free radicals was that of F. O. Rice (Catholic University, Washington), who found a transient blue substance, attributed to the imine radical, in the condensed products of dissociation of NH_3. Rice illustrated this early experiment, as well as later work, by means of excellent colour films which he recommended as being more reliable than the actual experiment for demonstrations of this kind. G. Wilse Robinson and M. McCarty (Johns Hopkins University, Baltimore) reported some very interesting and successful work on the stabilization of diatomic and triatomic radicals at 4° K. The radicals NH, OH, CH, C_2, NH_2, HNO, HCO and CNO. prepared in the electrical discharge, have been positively identified in a rigid argon matrix by means of their electronic absorption spectra. The spectra are surprisingly sharp and reveal that radicals such as NH_2, NH and OH experience nearly free end-over-end rotation in the matrix.

Most successful work on the aliphatic radicals has utilized electron spin resonance methods since their electronic spectra lie in the far ultra-violet, and infra-red methods present many problems. For example, H. W. Brown (National Bureau of Standards) was not able to obtain the infra-red spectrum of methyl by photolysis of methyl iodide, but K. Jen successfully used this method to record its electron spin resonance spectrum. M. S. Matheson (Argonne National Laboratory) summarized the radicals which have so far been identified in the irradiation products of paraffins, alcohols, ethers, aldehydes, ketones, fatty acids and other aliphatic compounds. The electron spin resonance spectra of the simple alkyl radicals are now well established. The ethyl radical is formed by the γ-irradiation not only of ethane but also of ethylene, and R. Klein and M. D. Scheer (National Bureau of Standards) described studies of the reactions of hydrogen atoms with solid olefins at 77° K. which show that addition occurs readily under these conditions. The γ-irradiation of alcohols and ethers is very specific in removing almost exclusively the hydrogen atom from the carbon α to the oxygen. D. J. E. Ingram and M. C. R. Symons (University of Southampton) described how the same radicals are also formed by photolysis of a solution of hydrogen peroxide in the rigid alcohol; the OH radical first formed readily abstracts hydrogen from the alcohol at 77° K.

For the aromatic radicals electronic absorption spectroscopy has proved to be most useful. H. T. J. Chilton G. Porter (University of Sheffield) and E. E. Strachan (British Rayon Research Association) described the preparation and stabilization of a variety of such radicals both by photolysis and by gamma radiolysis of rigid solutions at 77° K. In the case of the ionizing radiations the dissociation of the aromatic molecules is brought about almost exclusively by transfer of energy absorbed by the solvent.

The irradiation of polymers leads to larger radicals, and these are often still present at normal temperatures. For example, V. V. Voevodsky (Academy of Sciences, U.S.S.R.) described electron spin resonance studies of radicals trapped in irradiated polytetrafluoroethylene at 77° K., some of which remain when the specimen is warmed to 20° C. Radicals are also trapped in polymers as a result of the polymerization reaction itself and are responsible for unusual and characteristic kinetic behaviour. C. E. H. Bawn, T. P. Hobin and W. J. McGarry (University of Liverpool) described studies of trapped radicals in acrylonitrile, vinyl chloride, styrene and vinylidene chloride.

The general occurrence of stabilized radicals in polymeric and biological systems was reviewed by C. H. Bamford and A. D. Jenkins (Courtaulds, Ltd., Maidenhead). Electron spin resonance measurements have shown that metabolically active plant and animal tissues such as leaves, roots, seeds, blood, muscle and liver have a remarkably high radical content, and W. Gordy (Duke University) described recent investigations on such systems. Their function and the means by which they are stabilized and, indeed, their chemical nature are little understood as yet. J. L. Vivo-Acrivos and M. S. Blois (Stanford University, California) reported on electron spin resonance studies of stable radicals in natural and synthetic melanins. D. K. Ghosh and D. H. Whiffen (University of Birmingham) described their detailed work on the electron spin resonance spectra of radicals trapped in a single crystal of glycine after gamma irradiation. It can be shown that the radical is $^{+}NH_3.CH.COO^{-}$. The spectrum is anisotropic and shows far more detail than that from a polycrystalline material. The arrangement of the trapped radicals has the same symmetry as that of the molecules in the host lattice.

Although the major effort in the field of radical stabilization is at present directed towards the identification of the trapped species, it is clear that, once the spectra have been assigned, the method will provide a powerful means of investigation in many fields, and particularly of the primary processes of photochemistry, radiation chemistry and the electrical discharge. Masterly reviews of these three aspects of the subject were given by H. Linschitz (Brandeis University), M. S. Matheson and H. P. Broida. There was considerable discussion of the characteristic behaviour of excited states in rigid media, and Broida stressed the need for more information about the matrix structure and about the fundamental limitations to trapped radical concentrations.

There has been a great deal of interest in the possible use of stabilized radicals as high-energy rocket propellants. The important quantity to be considered is the heat of reaction per gram, and there seems little hope of increasing this greatly above 3 kcal./gm. with conventional molecular fuels. If pure atomic hydrogen could be utilized, the heat of reaction would be 51·2 kcal./gm., but the present indications are that concentrations which can be trapped are limited to 1 per cent or less. Other, heavier radicals are all much less suitable, and G. C. Szego (General Electric Co., Cincinnati) concluded that, at present, this application of stabilized radicals is not promising. Some enthusiasm was shown about the possibility of utilizing metastable excited states, such as the triplet state of helium, which has an excess energy of 113 kcal./gm.

Special experimental techniques are mainly concerned with the adaptation of existing methods to low temperatures. L. J. Shoen, L. E. Kuentzel and H. P. Broida (National Bureau of Standards) described glass Dewar flasks for optical studies at low temperatures, P. Le Goff and L. P. Blanchard (University of Nancy) described a mass spectrometer with a low-temperature ionization chamber, and H. S. Peiser (National Bureau of Standards) gave an account of his very elegant X-ray crystallographic studies on low-temperature solids.

The enthusiasm of the discussions was typical of a field where new phenomena are found in nearly every experiment which is performed. The international character of the meeting was a very pleasant feature, and this was assisted by financial support from the United States Department of the Army through its European research office.

GEORGE PORTER

NEW POTENT REACTIVATORS OF ACETOCHOLINESTERASE INHIBITED BY TETRAETHYL PYROPHOSPHATE

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CERTAIN organophosphates, for example, tetraethyl pyrophosphate (TEPP), di*iso*propyl phosphonofluoridate (DFP), diethyl *p*-nitrophenylphosphate (*E* 600), and a number of widely used insecticides and their metabolites, are potent inhibitors of acetocholinesterase. Organophosphate poisoning (fatal when sufficient acetylcholine has accumulated in the body) has been reported from many countries, especially from Japan[1] and the United States[2], and an efficient treatment has become essential. Acetocholinesterase is reputed to possess positively and negatively charged regions, commonly called anionic and esteratic sites, which participate in the hydrolysis of acetylcholine. In the inhibition process, a dialkylphosphoryl group, or some related group, becomes attached to the esteratic site and in this way deprives the enzyme of its hydrolytic function[3]. Spontaneous reactivation of diethyl phosphoryl-acetocholinesterase occurs very slowly, but the formation of di*iso*propyl phosphoryl-acetocholinesterase is, for all practical purposes, irreversible[4].

Certain nucleophilic reagents restore the activity of freshly phosphorylated acetocholinesterase by displacing the phosphoryl group from the enzyme[3]. Hitherto, pyridine-2-aldoxime methiodide has proved, in general, to be the most potent reactivator, and attachment of its quaternary nitrogen to the anionic site of the phosphorylated enzyme has been considered to contribute to its potency[5].

During the past two years we have synthesized a large number of oximes and studied the affinity of these compounds for acetocholinesterase, their interaction with tetraethyl pyrophosphate, and their effectiveness in restoring the activity of acetocholinesterase inhibited by tetraethyl pyrophosphate. The compounds can be classified roughly as aliphatic oximes, and compounds related to pyridine, indole, indolinene, quinoline and *iso*quinoline. The most powerful reactivators that have so far emerged are structurally related to pyridine, the effectiveness of some of these being shown in Tables 1 and 2. Monoximes and dioximes of *bis*-pyridinium ions (compounds 12–18; Table 2) are all considerably more potent reactivators than pyridine-2-aldoxime methiodide (*P*-2-*AM*) although they are derivatives of the less active pyridine-4-aldoxime methiodide (*P*-4-*AM*). A considerable gain in activity is also obtained by terminal halogen substitution in the alkyl side-chain (compare compounds 3 and 8). Table 2 shows that the reactivating power of the oximes cannot be predicted from their hydrolytic activity and their affinity for the anionic site of acetocholinesterase. The order of activities found :

$$P\text{-}2\text{-}AM > P\text{-}4\text{-}AM \gg P\text{-}3\text{-}AM$$

is in conformity with unpublished results obtained with other compounds, which suggests that a conjugative connexion between the quaternary nitrogen and an oxime or hydroxamic acid group is an essential feature for high activity.

All the compounds in Table 2 have been subjected to a preliminary screening for antidotal properties.

TABLE 1

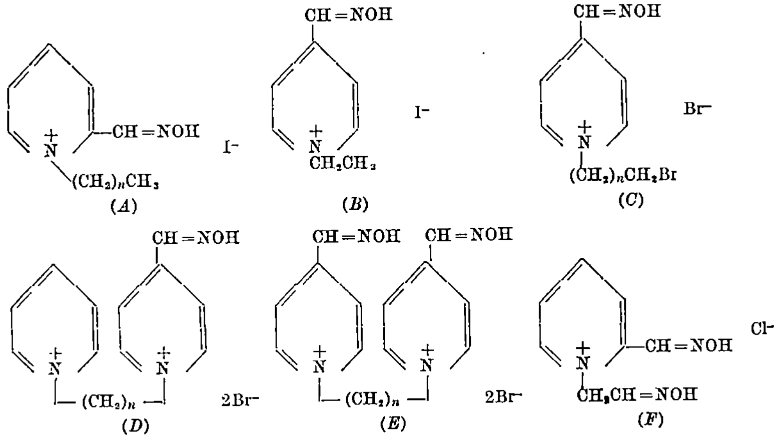

TABLE 2. *In vitro* REACTIVATION OF HUMAN ACETOCHOLINESTERASE INHIBITED BY TETRAETHYL PYROPHOSPHATE

No.	Oxime	Melting point (°C.)	*A* Potency as reactivator	*B* Calculated value for *A*	*C* Ratio $\frac{A}{B} \times 100$
1	*P*-2-*AM*	225	100	100	100
2	*P*-3-*AM*	156	0·03	11	0·27
3	*P*-4-*AM*	179	6	26	23
	(*A*)				
4	$n = 1$	180	54	210	26
5	$n = 2$	192	63	560	11
6	$n = 3$	168	87	6,780	1·3
7	(*B*)	152	3	18	17
	(*C*)				
8	$n = 0$	245	160	80	200
9	$n = 2$	165	190	750	25
10	$n = 3$	144	25	790	3·2
11	$n = 4$	164	94	160	58
	(*D*)				
12	$n = 3$	225d	800	42	1,900
13	$n = 4$	235d	670	21	3,200
14	$n = 5$	195	750	87	8,600
	(*E*)				
15	$n = 2$	310	1,700	110	1,500
16	$n = 3$	239d	2,200	95	2,400
17	$n = 4$	240d	1,800	100	1,800
18	$n = 5$	209d	1,600	740	210
19	(*F*)	196	20	220	9

Washed human red cells were used as enzyme source and results obtained with *P*-2-*AM* were taken as 100. *B* is the affinity of the oxime for acetocholinesterase × rate of interaction of the oxime with 2×10^{-3} *M* tetraethyl pyrophosphate. All experiments were carried out at 37° C. with 0·01 *M* acetylcholine chloride as substrate in a medium of 0·025 *M* sodium bicarbonate equilibrated with 95 per cent nitrogen + 5 per cent carbon dioxide. The method for determining *A* was in principle that described previously (ref. 9), except that reactivation was allowed to proceed in the centre of the manometric vessel for 30 min. before addition of the substrate.

Table 3. PROTECTION BY OXIMES AGAINST LETHAL TETRAETHYL PYROPHOSPHATE POISONING

Compound	No. of mice surviving for 24 hr./No. of mice injected					
	µgm. Tetraethyl pyrophosphate injected per mouse					
	8	16	32	64	128	256
—	5/6	0/8	0/6	0/6	0/6	0/6
P-2-*AM*	—	0/6	0/18	0/4	—	—
12	—	4/4	3/6	1/4	—	—
13	—	—	5/6	1/4	—	
14	—	—	5/6	4/4	3/5	0/5
15	—	4/4	2/6	1/4	—	—
16	—	—	6/6	4/4	5/5	7/15
17	—	—	6/6	4/4	4/5	0/5

Compounds were administered in amounts equimolar to 0·5 mgm. *P*-2-*AM* per mouse. Male white mice weighing between 18 and 20 gm. were injected intraperitoneally with 0·2 ml. of the oxime in 0·9 per cent sodium chloride solution and then 5 to 8 min. later they were injected subcutaneously with 0·2 ml. tetraethyl pyrophosphate in 0·9 per cent sodium chloride solution. Mice injected with the oximes alone showed no visible changes.

As can be seen from Table 3, under the experimental conditions chosen, some oximes and dioximes of *bis*-pyridinium ions are markedly superior to pyridine-2-aldoxime methiodide as antidotes to tetraethyl pyrophosphate *in vivo*. If tolerated satisfactorily, they will be considerably superior to pyridine-2-aldoxime methiodide in restoring the activity of acetocholinesterase in human beings poisoned by organophosphates. This is of great potential importance since most of the new compounds listed in Table 3 are more soluble and appear to be more stable than pyridine-2-aldoxime methiodide, and also in view of the reported observation that 1 gm. of the latter, injected intravenously, restores the activity of erythrocyte acetocholinesterase in human beings poisoned with parathion, but has only a disappointingly small influence on the phosphorylated enzyme formed by other organophosphates[6].

It might be expected that oximes of relatively low toxicity which, in relation to pyridine-2-aldoxime methiodide, have a higher affinity for acetocholinesterase or hydrolyse tetraethyl pyrophosphate more rapidly, would protect animals against lethal tetraethyl pyrophosphate poisoning to a greater extent than pyridine-2-aldoxime methiodide. Compounds 6, 9 and 10 have a 64-, 17- and 22-fold higher affinity than pyridine-2-aldoxime methiodide for acetocholinesterase, and compound 8 is 2·6 times more effective than pyridine-2-aldoxime methiodide in hydrolysing tetraethyl pyrophosphate. However, under the experimental conditions of Table 3, compounds 6, 8, 9 and 10 failed to protect mice from a lethal dose of 32 µgm. tetraethyl pyrophosphate.

A complete account of this work is to be published elsewhere. While this work was in progress, two reports[7,8] have appeared describing the reactivating and the antidotal effect of compound 16 in animals poisoned with sarin. Discrepancies between the findings of these authors and the results presented here probably arise from differences in the type of phosphorylated enzyme.

Should the results obtained with compound 16 be applicable to other species, pyridine-2-aldoxime methiodide becomes obsolete as an antidote for tetraethyl pyrophosphate poisoning. Since many of the insecticides used at present form diethylphosphoryl-acetocholinesterase, there is a good chance that compound 16 will be highly effective in many cases of accidental organophosphate poisoning which are frequently reported.

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ADRENALINE/NORADRENALINE RATIO IN THE ADRENAL GLANDS OF THE HEDGEHOG DURING SUMMER ACTIVITY AND HIBERNATION

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WE have recently published figures for the adrenaline and noradrenaline content of the adrenal glands of the hedgehog during the summer[1]. The adrenal glands of the active hedgehog with a normal body temperature contain considerable amounts of noradrenaline, the values being 40 per cent of the total catechol amine content in the male, and rather less in the female. With regard to the adrenaline/noradrenaline ratio, the hedgehog belongs to the same type as the cat family.

In continuation of this study, we have determined the catechol amines in the adrenal glands of the hedgehog at other times of year, and especially during natural hibernation. The adrenaline and noradrenaline were separated by paper chromatography, eluted and determined biologically (chiefly by their effect on the blood pressure or colon of the rat). We have also made histochemical determinations by Hillarp–Hökfelt's reaction[2].

The average values of these biological determinations for the different seasons are presented in Table 1 and Fig. 1. From these it is seen that the adrenaline/noradrenaline ratio in the adrenal glands of the hedgehog changes towards the end of September, as the result of a fall in noradrenaline content. The hedgehogs are then still homoiothermic. At the end of November an investigation was made on two hedgehogs which had already entered into hibernation and become hypothermic. In the adrenals of one of these, the adrenal content had increased. In mid-winter, when the hedgehogs were in deep hibernation, the noradrenaline content of the adrenals was consistently very low, while simultaneously the value for adrenaline was usually found to be strikingly high. At this time the adrenal glands of the hedgehog resemble those of the rat with regard to the adrenaline/noradrenaline ratio. When the hedgehog had emerged from hibernation in the natural way in spring, the noradrenaline content of the adrenals had clearly increased and the adrenaline content again decreased. The noradrenaline content appears to increase in the early spring, while the hedgehog is still in the hibernating state. At this time the adrenaline content of the adrenals has not yet decreased.

For comparison, we have also estimated noradrenaline and total catechol amines histochemically by means of Hillarp–Hökfelt's reaction[2]. The depth of staining of the microscopic preparations has been measured photometrically with a photocell connected with the microscope tube. The values obtained are only roughly relative. The darker the preparation, the greater is the photocell index.

The average values of the photometric measurements are given in Table 2. It will be seen that the noradrenaline and total catechol amine contents change in the same way, broadly speaking, as in Fig. 1. The ratio of noradrenaline to total catechol amines cannot be estimated in this way.

The natural hibernation and hypothermy of the hedgehog is a cold stress. The general adaptation syndrome is already developed by autumn, however, before the hedgehog hibernates[3,4]. This condition is a clear alarm reaction. In adrenals investigated a couple of weeks before the onset of hibernation, the cortex had passed into the resistance stage of the adaptation syndrome. In hibernation, the resistance stage seemed to continue. The cortex appears to be particularly active in deep hibernation, for example, during periods of intense cold in mid-winter.

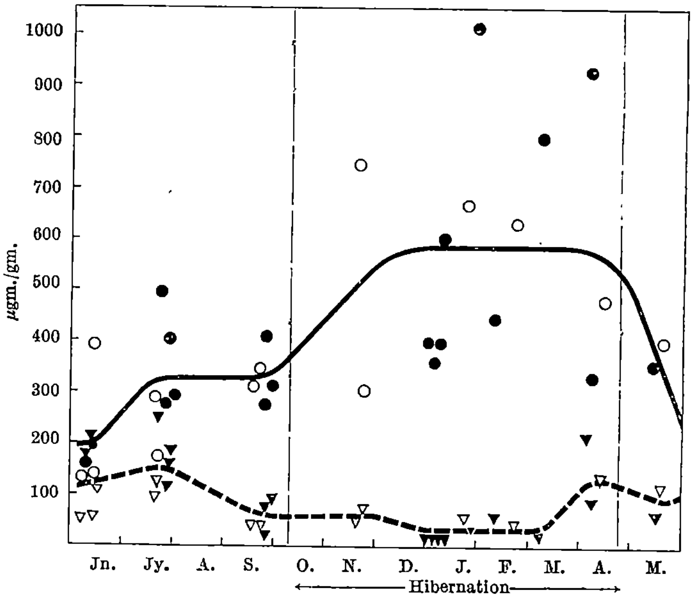

Fig. 1. Adrenaline and noradrenaline content of the adrenal glands of the hedgehog in different seasons. ——, Adrenaline, ● (♂), ○ (♀); – – –, noradrenaline, ▼ (♂), ▽ (♀)

Table 1. ADRENALINE AND NORADRENALINE CONTENT OF THE ADRENAL GLANDS OF THE HEDGEHOG IN DIFFERENT SEASONS

Season	No. of animals	Body-weight (gm.)	Adrenal weight		Catechol amines				Condition
			Absolute weight (mgm.)	Relative weight (mgm./100 gm. body-weight)	Total (μgm./gm. adrenal weight)	Adrenaline (μgm./gm. adrenal weight)	Noradrenaline (μgm./gm. adrenal weight)	Noradrenaline per cent	
Early summer	5	560	389	69·5	320	199	121	37·8	Awake
Midsummer	6	650	305	46·9	493	338	155	31·4	
Autumn	4	458	253	55·2	387	332	55	15·0	
Early winter	2	378	231	61·1	587	526	61	10·4	Hibernating
Midwinter	9	498	239	48·0	617	585	32	5·2	
Early spring	3	385	218	56·6	713	576	137	19·2	
Spring	2	645	267	41·4	462	380	82	17·7	Awake

When hedgehogs were investigated in spring, after they had emerged from hibernation in Nature, the histological picture presented by the adrenals was rather different in different individuals. In some specimens the adrenals were evidently in a slight alarm reaction, whereas in others the cortex was slightly active. By the end of May or in the beginning of June, the function of the cortex seemed to have become normal.

It is believed that adrenocorticotrophic hormone is secreted in proportion to the momentary degree of bodily stress. Injections of adrenaline or sympathetic stimulation are known to cause an enormous increase in the production of adrenocorticotrophic hormone and adrenocorticoids. Consequently, it is believed that the reaction to stress is at least largely due to the fact that adrenaline has a direct or indirect effect on the anterior pituitary gland, increasing the secretion of adrenocorticotrophic hormone. Evidently the neurosecretion from the hypothalamus also participates in the activation of the anterior pituitary and the adrenal cortex[5].

As yet, we have not determined the adrenaline from the blood during hibernation. It is noteworthy, however, that the adrenaline content of the adrenals of the hedgehog usually increases just at the time when the cortex, too, is activated on account of physiological stress. This is especially the case during periods of intense cold in midwinter. But even in autumn, before the onset of hibernation, the ratio of adrenaline to noradrenaline has already increased. The high adrenaline content of the adrenals during hibernation fits in well with Selye's results, according to which "during the stage of resistance the adrenal medulla regains its chromaffinity"[6]. In spring, when the hedgehog emerges from hibernation and changes again from hypothermy to homoiothermy, the adrenaline content of the adrenals decreases greatly, as it usually does in a strong alarm reaction.

The question of what factors are responsible, despite the increase in the adrenaline content of the adrenals, for the various special features of the hedgehog's hibernation, such as the marked bradycardia, hypoglycæmia and steady glycogen content of the liver and muscles throughout hibernation[3,4], will be discussed elsewhere.

Table 2. RELATIVE PHOTOCELL INDICES FOR HISTOCHEMICAL DETERMINATIONS OF THE TOTAL CATECHOL AMINES AND NORADRENALINE IN THE ADRENAL GLANDS OF THE HEDGEHOG

	Total catechol amines	Noradrenaline
Summer	4·7	2·1
Autumn	4·4	1·3
Early winter	4·9	2·1
Midwinter	5·1	1·4
Early spring	4·9	1·1
Spring	4·6	1·6

In Table 1 attention is directed to the low noradrenaline content of the adrenals during the time of deep hibernation. At this stage of our experiments the physiological significance of this change cannot be explained. There is a dual physiological requirement of noradrenaline: (1) a local, intra-adrenal one as a metabolic precursor of adrenaline; and (2) a general, extra-adrenal one as a real independent hormone. The increase in the noradrenaline content of the adrenals in spring and summer might indicate at least an increased local need. Whether the notable decrease in the noradrenaline content of the adrenals during hibernation should then be taken to mean that its formation has decreased or that its extra-glandular requirement has increased is difficult to say before measurements have been made of the secretion of catechol amines into the blood in the different seasons of the hedgehog's activity. Hsieh and Carlson[7] have recently shown that noradrenaline had little effect in warm-adapted rats, but a marked calorigenic response in cold-adapted rats. Noradrenaline may thus play an important part in the chemical regulation of heat production in cold-adapted animals.

When the animal awakes from hibernation and becomes homoiothermic again, the rewarming of the anterior half of the body takes place much more rapidly than that of the posterior half[8,9]. Lyman and Chatfield have shown[9] that vasoconstriction takes place in the vessels of the posterior part of the body and in the intestines caudal to the liver. The blood then circulates only in the anterior part of the body. All the heat produced by the heart and the muscles of the anterior trunk serves to warm the front half of the body. What connexion may exist between the variation in the noradrenaline and adrenaline content, in addition to any other possible vasoconstrictory substances, and such changes in vasoconstriction and vasodilation is still unknown.

It seems to us obvious that the results presented above are in harmony with the view that the physiological production of the different catechol amines in the adrenal glands is controlled by separate hypothalamic centres[10].

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HYPERCHROMICITY AND NUCLEIC ACIDS

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DEGRADATION of ribonucleic acids by alkali, ribonucleases and other reagents, and of deoxyribonucleic acids on treatment with deoxyribonucleases or on denaturation, is accompanied by an increase in ultra-violet absorption, normally measured in the region of 260 mμ, the absorption maximum for nucleic acids. In view of the profound importance of the anomalous ultra-violet absorption characteristics of nucleic acids in relationship to the fine structure of the macromolecule, the hyperchromicity of a number of relatively simple polynucleotide derivatives was studied. It should, perhaps, be emphasized that, except as otherwise described, the specimens used were synthetic[1] and as such contained a mixture of 3′ : 5′ and 2′ : 5′ internucleotide linkages, in contrast to natural and biosynthetic polymers, which have 3′ : 5′ linkages exclusively. The results are given in Table 1. Contrary to statements in the literature[2] that hyperchromicity is not due to the simple union of a few mononucleotides, it can be seen that appreciable values are obtained even for dinucleotide derivatives, in agreement with the observations of Sinsheimer[3] and of de Garilhe and Laskowski[4] that small oligodeoxynucleotides have about a 10 per cent hyperchromic effect. Thus, even a simple dinucleoside phosphate—adenosine-2′ uridine-5′ phosphate[5]—exhibits a hyperchromicity of 12·8 per cent (as does the analogous adenosine-2′(3′) thymidine-5′ phosphate[6]), whereas in the polyadenylic series, hyperchromicity rapidly reaches a limiting value of approximately 35 per cent at chain lengths of 5–6.

In view of the zero hyperchromicity of polyguanylic acids at alkaline pH's, the variation of hypochromicity with pH was examined for a number of derivatives (Table 2). The results indicate that while ionization of the purine or pyrimidine moiety has a pronounced effect in certain cases, hydrogen bonding between the bases cannot be accepted as a cause of hyperchromicity in simple nucleotide derivatives.

Table 1

Compound	Average chain length	$\lambda_{max.}$ in 0·2 N sodium hydroxide		Alkaline hyper-chromicity
		Polymer (mμ)	Products (mμ)	
A 2′(3′)P	—	—	259·5	0
Diadenylic acid	—	258·5	259·5	15·1
Triadenylic acid	—	258	259·5	22·8
Tetraadenylic acid	—	258	259·5	30·7
Pentaadenylic acid	—	258	259·5	32·9
Polyadenylic acid	7·7	258	259·5	31·8
Polyadenylic acid	13·6	257·5	259·5	36·7
Polyuridylic acid	6·6	261	261	6·5
Polyuridylic acid	11·9	261	261	8·6
Polyguanylic acid	5·4	260–266	260–266	0
Polyguanylic acid	12·5	260–266	260–266	0
A 2′P5′U	—	261	260	12·8
A 3′P5′C3′P (from RNAase digest)	—	262	262	7·2
Synthetic RNA	12·5	260	261	14·3
Yeast RNA	12·2	260	261	12·0
RNAase-resistant cores	6·2	259	260	10·9
PolyAU (4·5:1) random	5·2	259	260	21·1
PolyAU (1·4:1) random	8·3	259·5	261	13·4
PolyAU (3·1:1) tracts	5·3	259	260	22·9
PolyAG (1·9:1) random	6·2	258	260	19·0

Key: A, adenylic acid; U, uridylic acid; G, guanylic acid; RNAase, ribonuclease; RNA, ribonucleic acid; P, phosphate.

Table 2

Acid	Hyperchromicity		
	0·01 N hydrochloric acid	Water (pH 7)	0·2 N sodium hydroxide
Diadenylic	0	—	15·1
Triadenylic	6·8	—	22·8
Tetraadenylic	13·2	—	30·7
Pentaadenylic	16·4	—	32·9
Polyadenylic (13·6)	22·9	—	36·7
Polyguanylic (3·2)	9·0	10·3	0
Polyguanylic (5·4)	14·6	16·5	0
Polyguanylic (12·5)	18·0	23·0	0
Polyadenylicguanylic (6·2)	14·7	36·7	19·0
A2′P5′U	12·3	16·0	12·8

While the results for polyguanylic acid are possibly an extreme example of the variation of hyperchromic effect with pH, it is clear that the effect of pH on the ultra-violet absorption of a large nucleic acid, relative to that of its component mononucleotides, will be a composite of many different curves, characteristic not only of the nucleotide composition but also of the order of bases in the polymer. The hyperchromic effect on degradation of the polymer is likewise a function not of any particular tract of nucleotides but of the total molecule determined by both the composition and order of the various bases.

It may be noted that in addition to the reduction in ultra-violet absorption there is also a small hypsochromic shift accompanying polymer formation, as has been reported by Warner[7] for biosynthetic polymers of high molecular weight.

Pronounced changes in the apparent pK values of the bases have also been observed. While in biosynthetic polymers of high molecular weight this could be due to hydrogen bonding in a macromolecular structure, in the smaller synthetic materials this is unlikely. Thus, the apparent pK of 2·32 found for guanosine-2′(3′) phosphate is shifted to 2·63 for polyguanylic acid (average chain-length 5·4 nucleotides), while that at 9·33 shifts to 10·76 for polyguanylic acid with an average chain-length of 5·4 units and to 11·20 for polyguanylic acid (average chain-length 12·5), using spectrophotometric titration to estimate apparent pK (Fig. 1).

Since the ionizable groups participate directly in the electron system giving rise to the absorption, any perturbation of the π-electron system of the purine or pyrimidine ring will have an effect on such groups. It is therefore considered that the hypochromic effect observed on formation of polynucleotides is essentially due to the interaction of π-electrons of adjacent rings (cf. refs. 8 and 9), with the formation of electron orbitals extending over more than one unit, orientated normal to the planes of the ring systems stacked in layers above each other, forming essentially a new electronic species. While this interaction has an effect on the ionizable groups, it is clear that perturbation of these groups—by hydrogen bonding, or by ionization—will also have its effect on the total chromophoric system, without, however, breaking the π-bond interaction between the bases, which exists even at the dinucleotide-level and at all values of the pH. Variation in ionic strength, changing the macromolecular configuration and distribution of charge in the vicinity of the chromophore, will also have an effect on this interaction and hence on the ultra-violet absorption.

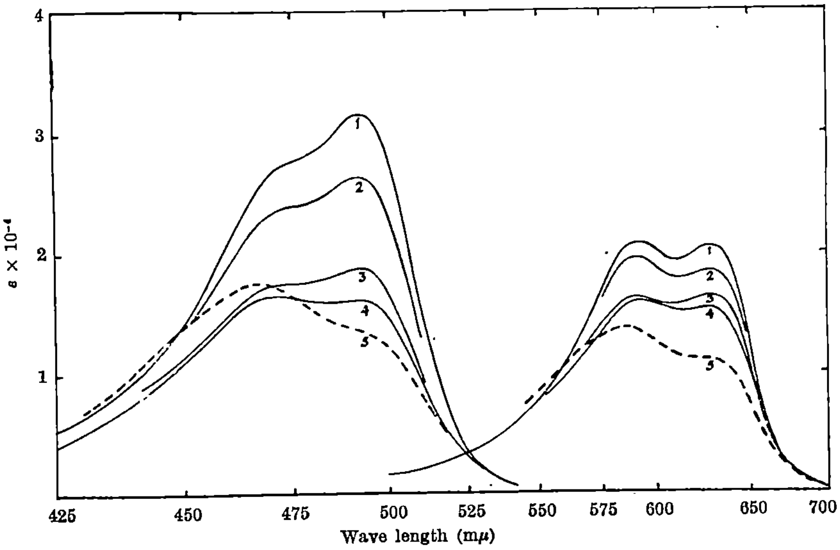

Fig. 2. Action of polynucleotides (3 × 10^{-5} M) on the absorption of acridine orange (3 × 10^{-5} M)—left; and toluidine blue (3 × 10^{-5} M)—right, in 0·01 M ammonium acetate at pH 6·8. 1, Dye alone; 2, 3, 4 and 5, with added polyuridylic acid, polyadenylic acid, polyguanylic acid and yeast ribonucleic acid, respectively

In view of the extensive work on the binding of various planar basic dyes and amino-acridines with nucleic acids, the effect of some low molecular weight synthetic polymers (average chain-length approximately 6) on the absorption spectra of rosaniline, toluidine blue and acridine orange was examined (Fig. 2). In all cases the effects due to the synthetic polymers were smaller than those observed with yeast nucleic acid. Since the linkages in the synthetic materials are mixed 2′–5′ and 3′–5′, the arrangement of phosphate groups along the backbone is not as uniform as in the natural material, so that while all sites may have been occupied, only where tracts of 2′–5′ or of 3′–5′ linkages occurred would any metachromasy result, giving rise effectively to 'dimeric' binding, rather than 'polymeric', using Lawley's[10] definition of the terms. Marked quenching of the fluorescence of acridine orange was also observed, particularly by polyguanylic acid and to a lesser extent by polyuridylic acid. Polyglycerophosphate[6] with an average chain-length of 12·1 glycerophosphate units was quite without effect on the absorption of these dyes or on the fluorescence of acridine orange, indicating the stereospecific requirements of the phosphate binding sites leading to induced metachromasy. That this induced metachromasy is a direct parallel to the similar effects observed in concentrated solutions of such dyes, and to the hypochromicity of polynucleotides, is further suggested by work which has shown that the forces operating between the rings of the neighbouring ions of dye aggregates have an equilibrium distance of 3–4 A.[11,12].

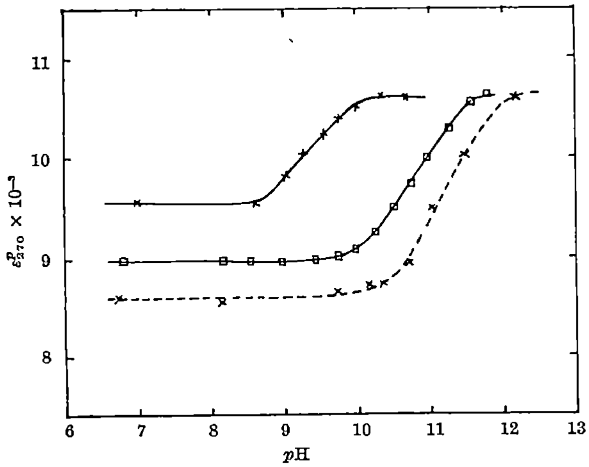

Fig. 1. Spectrophotometric titrations at 270 mμ of guanosine-2′(3′) phosphate —×—×—, polyguanylic acid (average chain-length 5·4) —☐—☐—, and polyguanylic acid (average chain-length 12·5) --×--×--

These three lines of evidence—the hyperchromic degradation of polymers, the corresponding hypochromic effect on the absorption of dyestuffs in combination with the polymer and the shift in apparent pK of the ionizable groups—point to a definite configuration for small polynucleotides and imply a restricted rotation about the internucleotide linkage even for dinucleotides. That the configuration favouring interplanar interaction may be of lower energy than other configurations has been shown by the effect of adenosine on the spectrum and fluorescence of riboflavin, particularly in flavin adenine dinucleotide[13].

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LETTERS TO THE EDITORS

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Glucuronate Metabolism by *Aerobacter aerogenes*

THE initial reaction in the utilization of D-glucuronic acid by a number of bacterial species is catalysed by uronic isomerase[1-3]. The enzyme is constitutive in organisms that utilize glucuronate and induced in those organisms that become adapted to the utilization of glucuronate (refs. 2, 3 and unpublished work by Payne, W. J.).

The D-fructuronic acid formed by isomerase action may be converted afterwards to L-gulonic acid by a second enzyme, keturonic reductase, in the presence of reduced pyridine nucleotides, although reductase activity could not be demonstrated in all organisms studied[3]. The latter deficiency, and the fact that organisms adapted to uronate are not adapted to utilization of xylitol or the homologous aldo- or keto-pentoses expected from decarboxylation of gulonic acid, indicated that fructuronate might be metabolized by another pathway.

Table 1. PRODUCTS OF ANAEROBIC GLUCURONATE METABOLISM IN WHOLE CELLS

Anaerobic metabolism by	Δ Glucuronate (μmoles)	Δ Hydrogen (μmoles)	Δ Carbon dioxide (μmoles)	Δ Volatile acid (μmoles)
Aerobically adapted cells	− 1·0	0·0	0·0	+ 2·58
Anaerobically adapted cells	− 1·0	+ 1·95	+ 1·70	+ 2·04

Products of the anaerobic metabolism of glucuronate by cells of *Aerobacter aerogenes* adapted to glucurate utilization under aerobic and anaerobic conditions gave the stoichiometry shown in Table 1. These results suggested a cleavage to 3-carbon units according to the pathway:

$$\begin{aligned} &\text{glucuronate} \\ &\quad\rightleftharpoons \\ &\text{fructuronate} \rightarrow (2\ \text{pyruvate}) \rightarrow 2\ \text{acetate} + \\ &\qquad\qquad\qquad 2\ \text{formate} \rightarrow 2\text{H}_2 + 2\text{CO}_2 \end{aligned}$$

The inability of aerobically adapted cells to produce gas is caused by the failure of such cells to form the hydrogenlyase system necessary for formation of hydrogen and carbon dioxide from formate. The formation of volatile acid without production of carbon dioxide by aerobically adapted cells excludes the possible decarboxylation of gulonic acid as an intermediate step in the pathway.

Confirmation of the cleavage to 3-carbon compounds was obtained by use of extracts of cells grown anaerobically on glucose or glucuronate and ground with alumina. Aldolase activity could be measured with 2,4-dinitrophenylhydrazine according to the method proposed for the measurement of the cleavage of hexose diphosphate[5], since the *bis*-2,4-dinitrophenylhydrazones formed from the products of fructuronate cleavage gave similar colour reactions. Prior phosphorylation to fructuronate-1-phosphate by adenosine triphosphate was necessary for the cleavage reaction (Table 2).

A comparison of the enzymatic activities of cells grown with glucose and with glucuronate shows that the kinase and aldolase activities are the result of constitutive enzymes, probably non-specific reactions of fructose-6-phosphate kinase and hexose diphosphate aldolase. The specific activity of the induced uronic isomerase in the extracts is presented for comparison. The low activity of the kinase–aldolase system is apparently the rate-limiting reaction in the pathway, which thus accounts for the accumulation of fructuronate previously observed with dried cells[6]. Production of fructuronate-1-phosphate by the reverse reaction in the presence of dihydroxyacetone phosphate and tartronic semialdehyde can be measured with the cysteine–carbazole reaction[7]. No fructuronate was formed when dihydroxyacetone phosphate was replaced by dihydroxyacetone in the incubation mixture unless adenosine triphosphate and magnesium were also present.

Table 2. COMPARISON OF THE ENZYMATIC ACTIVITIES IN EXTRACTS OF CELLS GROWN IN GLUCOSE AND IN GLUCURONATE

Additions	Enzyme(s) measured	C_6 compound metabolized (μmoles/hr./mgm. of protein)	
		Extract of cells grown in glucose	Extract of cells grown in glucuronate
Glucuronate	Uronic isomerase	0·00	18·60
Hexose diphosphate	Aldolase	7·24	2·86
Fructose 6-phosphate	Kinase + aldolase	0·00	0·00
Fructose 6-phosphate + adenosine triphosphate + magnesium ions		2·20	1·85
Fructuronate		0·00	0·00
Fructuronate + adenosine triphosphate + magnesium ions		0·09	0·05

The products of aldolase action, dihydroxyacetone phosphate and tartronic semialdehyde, are afterwards metabolized to acetate, hydrogen and carbon dioxide by extracts of anaerobically adapted cells. The dihydroxyacetone phosphate fragment is metabolized to pyruvate by normal glycolytic enzymes with the production of reduced diphosphopyridine nucleotide at the level of triose phosphate dehydrogenase. The reduced diphosphopyridine nucleotide is re-oxidized by hydrogen transfer to tartronic semialdehyde to yield, presumably, glyceric acid in the presence of another induced enzyme, tartronic semialdehyde reductase, which can be readily measured by the change in optical density at 340 mμ (Table 3). Non-adapted cells contain small amounts of tartronic semialdehyde reductase activity that may be the result of non-specific aldehyde reductase activity in the crude extracts. Reversibility of the reductase reaction could not be measured in the presence of the very active reduced diphosphopyridine nucleotide oxidase in the extracts.

Table 3. TARTRONIC SEMIALDEHYDE REDUCTASE ACTIVITY OF CELL EXTRACTS

Extract of cells grown in:	Reduced diphosphopyridine nucleotide oxidized (μmole/hr./mgm. of protein)
Glucose	0·07
Glucuronate	0·57

Glyceric acid and 3-phosphoglyceric acid are metabolized to hydrogen and carbon dioxide by similar extracts. Preliminary results suggest that there is an initial phosphorylation by adenosine triphosphate prior to utilization of glycerate, but no glyceric acid kinase could be demonstrated in the crude extract by direct methods.

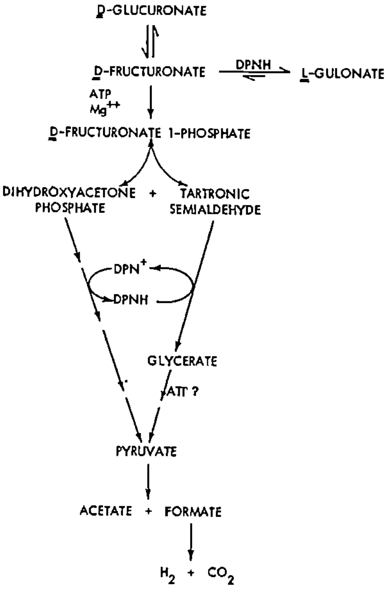

Fig. 1

Fig. 1 is a summary of the established reactions in the metabolism of glucuronate. The reactions leading to pyruvate probably represent the major pathway of glucuronate metabolism under aerobic as well as anaerobic conditions, since all the enzymes could also be demonstrated in extracts of aerobically grown cells.

Work is now in progress to isolate the enzymes from cells grown with glucose and with glucuronate, to determine the specificities of the induced and constitutive enzymes involved.

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Calcium and Phosphorus Metabolism after Surgery

Clinically, the view is widely held that major surgical operations may encourage the growth of metastases in patients with certain types of cancer (stage III breast carcinoma, Wilm's tumour, bone and soft tissue sarcomas). It is possible that operative stress may favour the spread of tumours by affecting the adhesion between cells. In view of the known relation between lack of adhesiveness and low calcium content[1], an investigation of calcium and phosphorus metabolism in patients undergoing surgery has been undertaken.

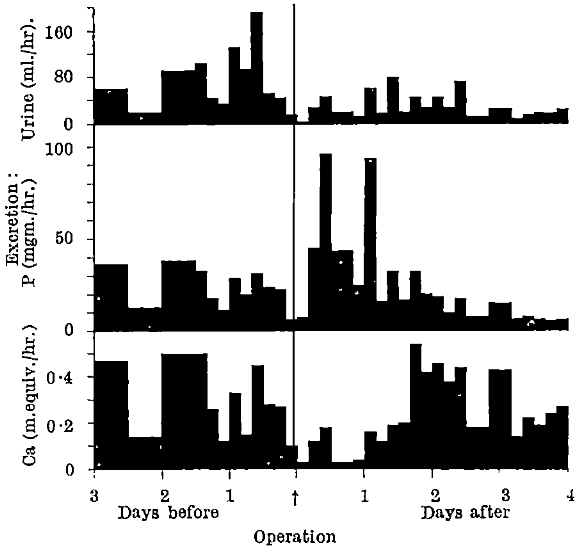

Fig. 1. The effect of a total hysterectomy (patient No. 246) on the urine, urinary phosphate and urinary calcium excretion rates

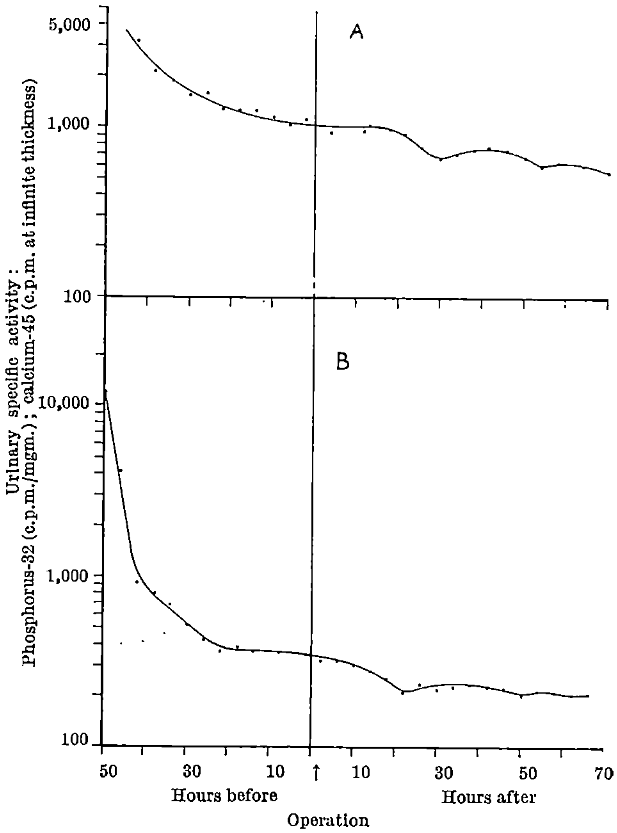

Fig. 2. *A*, The effect of a radical dissection of the inguinal lymph nodes (patient No. 611) on the specific activity of calcium-45 excreted in the urine (expressed as counts/min. of calcium oxalate at infinite thickness). *B*, The effect of an abdomino-perineal resection of the rectum (patient No. 486) on the specific activity of phosphorus-32 in the urine

Urinary excretion studies were carried out on 23 patients using four-hourly collection periods. Each collection has been analysed for calcium and inorganic phosphate and, in some cases, for total nitrogen, sodium, potassium, chloride and creatinine. Fig. 1 illustrates a calcium and phosphorus excretion pattern which has been found typical for uncomplicated major surgery. The phosphorus diuresis is a consistent finding and is usually observed to occur in association with retention of calcium.

Small doses of calcium-45 (14 µc.) and phosphorus-32 (20 µc.) have been administered parenterally to patients 48 hr. before surgery and the specific activity of the urinary calcium and phosphorus plotted against time[2]. In three out of eight patients studied, marked deviations from the expected calcium specific activity curve have been observed in the 48 hr. following operation (Fig. 2*A*). Two out of two phosphorus specific activity curves have shown a similar effect of operation (Fig. 2*B*).

It is suggested that the above observations are consistent with a post-operative calcium mobilization which, in most cases, could be associated with an increase in parathyroid activity. It could follow that surgical trauma produces a condition where there is a local or systemic demand by the tissues for calcium. This possibility, and the further speculation that changes in the calcium concentration of tissues may favour the spread and establishment of metastases, are at present being investigated.

We are indebted to the medical and nursing staff of the Special Unit for their generous co-operation.

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Changes in the Sensitivity of Enzymes in the Dry State to Radiation

THERE is now considerable evidence that the sensitivity to radiation of enzymes in the dry state is influenced by the medium in which the enzymes are dried.

It was first noticed that different, commercially available invertase preparations had different radiation cross-sections in the dry state in a vacuum. This observation led us to prepare invertase solutions from commercial yeast using the purification methods described by Dieu[1], Fisher and Kohtes[2], and Sumner and O'Kane[3]. Although the enzyme solutions were prepared from the same yeast, the sensitivity of the enzyme showed variations even at different stages of purification. In Table 1 some of these results are given.

It can be seen that on dialysis of the Dieu extract the sensitivity of the enzyme increases considerably. If the dialysate from the dialysed extract of the Dieu preparation is added again to the residue, the cross-section returns to that of the crude extract. After free SH groups had been shown to be present in the yeast extract, cysteine and glutathione were tested for protective ability and were found to decrease the cross-section of several enzymes. Drying the enzyme from acetate buffer or from salt solutions in some cases led to greater sensitivity to radioactivity. In Table 2 the relative radiation sensitivities (for 4-MeV. deuterons) of four different enzymes dried down in solutions of various compounds are listed. In general, the effect of a compound on the radiosensitivity varied with its concentration. The results in Table 2 were obtained with a quantity of the added compound approximately one to ten times that of the enzyme used. Increasing the amount of compound added did not appear to change the values in Table 2 very much.

Table 1. INACTIVATION CROSS-SECTION (A.^{2}) OF DRY YEAST INVERTASE. 40 MeV. α-particles. Cross-section in yeast cell, 2,000 A.^{2}

Purification method	Dieu	Sumner	Fisher
Crude extract	1,350 ± 50	1,400 ± 100	2,400 ± 100
Dialysed extract	2,500		2,300
Precipitation	3,200		1,900
Final product		2,550	3,800

Table 2. RELATIVE RADIATION SENSITIVITIES OF ENZYMES IN THE DRY STATE

Additive	Invertase	Ribonuclease	Papain	Urease
Pure	1·0	1·0	1·0	1·0
Cysteine	0·5	—	—	0·5–0·7
Glutathione	0·5	0·52 ± 0·10	—	—
Yeast extract	0·45	0·52 ± 0·10	0·6–0·8	0·8
Ribonucleic acid	—	0·41 ± 0·07		
Acetate buffer	1·4–1·6	4·8 ± 1·4		
Sucrose		2·6 ± 0·5		
Sodium chloride	1·5–3·5	0·98 ± 0·21		

The conclusion to be drawn from these results is that the effect of ionizing radiation can either be increased or decreased. Reduction in radiation sensitivity of dry materials by added substances has recently been reported by Norman and Ginoza for catalase[4] and ribonucleic acid[5] and has been frequently observed in radiation studies on high polymers[6].

Further details will be reported elsewhere. This work was supported by a contract from the U.S. Atomic Energy Commission.

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Radioprotective Action of 5-Hydroxytryptamine

TRYPTAMINE and its hydroxyl derivative are powerful radioprotective amines *in vivo*[1,2], but they also give rise to physiological changes. Bacq and Alexander[3] state that tryptamine is not a vasoconstrictor, but is nevertheless as good a radiation protector of mice as 5-hydroxytryptamine. However, tryptamine causes intense smooth muscle contraction, similar to its hydroxyl derivative[4,5]. While this pharmacological activity for tryptamine is much less, molecule for molecule[6], our studies indicate this also applies to its radioprotective properties in rats.

Both amines protect polymer irradiated in oxygenated solution *in vitro*[2], and Bacq and Alexander regard the protective action *in vivo* as one of competition for radicals (particularly HO_2) from radiolysis of water. Others[4] have suggested that protection *in vivo* may be due to an 'oxygen effect'.

Table 1. EFFECTS OF 5-HYDROXYTRYPTAMINE AND 5-HYDROXYTRYPTAMINE ANTAGONISTS ON LETHALITY, LOSS OF WEIGHT AND DIARRHŒA IN IRRADIATED RATS

Group* (Treatment)	No. of animals: mean weight (gm.)	No. of survivors (30 days)	Mean survival (days)	Weight loss, initial 10 days	Incidence of diarrhœa at fourth day (per cent)
		Experiment 1†			
Controls (saline)	15 (181)	0	8·07 (± 4·69)	35	100
5HT (0·5 × 10^{-5} mole)	15 (180)	9	21·40 (± 9·93)	11	13
LSD (0·6 × 10^{-7} mole)	15 (189)	0	9·93 (± 3·83)	48	64
LSD (0·6 × 10^{-7} mole) 5HT (0·5 × 10^{-5} mole)	15 (178)	1	11·33 (± 6·68)	14	50
		Experiment 2			
Controls (saline)	10 (145)	0	7·10 (± 2·03)	—	100
5HT (0·5 × 10^{-5} mole)	10 (145)	9	22·90 (± 6·17)	17	0
BAS-phenol (1·7 × 10^{-5} mole)	10 (148)	0	5·90 (± 2·65)	—	100
BAS-phenol (1·7 × 10^{-5} mole) 5HT (0·5 × 10^{-5} mole)	10 (151)	0	7·10 (± 3·48)	—	100
BAS-phenol (0·3 × 10^{-5} mole) 5HT (0·5 × 10^{-5} mole)	10 (146)	0	12·30 (± 1·97)	17	0
		Experiment 3			
Controls (saline)	10 (149)	0	5·10 (± 2·58)	—	100
5HT (0·5 × 10^{-6} mole)	10 (149)	4	20·70 (± 9·12)	30	10
BOL 148 (3 × 10^{-7} mole)	10 (150)	0	6·10 (± 2·38)	—	30
BOL 148 (3 × 10^{-7} mole) 5HT (0·5 × 10^{-5} mole)	10 (153)	0	8·80 (± 3·40)	—	71

* All injections given intraperitoneally; 5-hydroxytryptamine 5 min. before irradiation. For *d*-lysergic acid diethylamide, 1-benzyl-2-methyl-3-(2 aminoethyl) 5 methoxy indole hydrochloride (BAS-phenol) and BOL 148, single injections given 5 min. before irradiation, or 10 min. before irradiation were followed by 5-hydroxytryptamine.

† In experiments 1 and 2, Canberra Black stock rats were used in proportions of 2 males to 1 female for each group. In experiment 3 Wistar hooded female rats were used. All animals received 1,000 r. whole-body irradiation.

We have investigated the effect of pretreating rats with antagonists and specific anti-metabolites, preceding administration of 5-hydroxytryptamine and tryptamine, and its effect on acute lethality from total-body irradiation (1,000 r. X-rays). Results of some of these experiments are set out in Table 1, for the 5-hydroxytryptamine anti-metabolites, *d*-lysergic acid diethylamide (LSD), its brominated-derivative (BOL 148), and the anti-serotonin, 1-benzyl-2,5-dimethyl serotonin (BAS phenol)[6]. Acute lethality was assessed for a 30-day period following irradiation, as in previous experiments[7]. The loss of weight and incidence of diarrhœa in survivors was also charted.

Antagonists and anti-metabolites of 5-hydroxytryptamine alone had no significant protective action, but inhibited that of 5-hydroxytryptamine and tryptamine. Anti-histamines failed to influence the protective action of 5-hydroxytryptamine but the radioprotective action of histamine[8] was inhibited.

Atropine and dibenzyline, which respectively block two types of tryptamine receptors[9], in doses of 0·25 mgm. failed to influence the protective action of 5-hydroxytryptamine.

Tranquillization of rats with reserpine (20 mgm. per kgm.), 18 hr. before irradiation, did not influence lethality significantly. Given 5–10 min. before irradiation, a slight protection resulted which could be increased by pretreatment with iproniazid (100 mgm./kgm.) given 12 hr. before reserpine. However, administration of 5-hydroxytryptamine 5 min. before irradiation to reserpinized rats resulted in a radioprotective effect, comparable to 5-hydroxytryptamine alone in similar doses. Reserpine exerts a non-specific antagonism to 5-hydroxytryptamine and other amines in smooth-muscle preparations[10], and besides releasing and depleting these amines by a change from bound to free form, apparently reduces their capacity to react with cell receptors. An anti-metabolite (for example, 1-benzyl-2,5-dimethyl serotonin) is pictured as acting by excluding a structurally related metabolite (5-hydroxytryptamine) from combination with its normal specific reactant (5-hydroxytryptamine receptor)[11].

The results obtained point to a close correlation between the radioprotective action of certain amines *in vivo*, and their respective pharmacological actions. However, the narrow range of tissue oxygen tension, which governs the oxygen effect in radioprotection *in vivo*[12], seems an inadequate explanation for some of the results obtained, and in particular, the protection which results from the endogenous release of 5-hydroxytryptamine by combining reserpine with an amine oxidase inhibitor. The conception of radioprotection *in vivo* as largely one of competition for free radicals, also fails to afford a convincing explanation for the specificity of antimetabolites, in modifying the protective action of certain aromatic amines.

A full report will be published elsewhere. We thank Sandoz, Ltd., for liberal gifts of 5-hydroxytryptamine, lysergic acid diethylamide and BOL 148; Roche Products Pty., Ltd., for marsilid; and Merck and Co., Ltd., New York, for 1-benzyl-2,5-dimethyl serotonin, used in these experiments.

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Liberation of Invertase from Disintegrated Yeast Cells

MYRBÄCK[1,2] found that if baker's yeast was treated with ethyl acetate for 20 hr. at room temperature and then thoroughly washed with water on the centrifuge a large proportion of its invertase activity remained in the insoluble fraction even when this was stored for several months at room temperature. It has long been known[3] that only a small fraction of the total invertase can be removed from yeast cells by simple extraction procedures, some form of autolysis being needed to liberate the remainder. Myrbäck suggested that treatment with ethyl acetate removes from the cell the enzymes responsible for the autolytic release of the invertase, which therefore remains indefinitely in combination with insoluble cell structures.

We have confirmed the effect of ethyl acetate treatment, but have obtained additional evidence which indicates, contrary to Myrbäck's view, that yeast invertase does not occur in an insoluble form.

In our experiments we used baker's yeast from a factory at Libán, Czechoslovakia. 150 gm. was kneaded with 15 ml. redistilled ethyl acetate; it liquefied, and was then shaken for 20 hr. at room temperature. After dilution to 1,500 ml. with distilled water the insoluble fraction was separated and washed repeatedly on the centrifuge, the final wash being colourless and virtually devoid of invertase activity. The precipitate was suspended in water to a total volume of 150 ml., and when plated on wort-agar showed no sign of living cells. It was preserved at room temperature with chloroform.

The total invertase content of each batch of yeast was assumed to be the sum of the activities of the final ethyl acetate-treated suspension and of the first supernatant, measured by a polarimetric method. All results are expressed in units per gm. original pressed yeast, one unit being that quantity of enzyme which inverts 1 mgm. sucrose/min. from a 5 per cent solution at pH 4·7 (0·02 M sodium acetate buffer) at room temperature (20–22° C.).

Experiments were made with suspensions freshly prepared, or at most 7 days old. During this period not more than 5 per cent of the invertase activity passed into the suspending fluid. Samples were centrifuged and the precipitates crushed in the Hughes press[4]. For example, 10 ml. of a suspension was centrifuged (1,000g) on the day it was prepared and a known fraction of the precipitate transferred to the Hughes press, crushed at −30° C., and washed off the block and re-suspended with water so that 1 ml. corresponded to 0·5 gm. of original yeast. On centrifugation for 1 hr. at 35,000g a slightly opalescent supernatant was obtained. Its invertase activity was 57 units, compared with 65 units for the suspension before crushing and an estimate of 72 units in the original yeast.

This result suggests that the invertase in the intact yeast cell is enclosed by membranes which are not permeable to it, and which are not sufficiently damaged by ethyl acetate treatment to allow it to escape. It is conceivable that one of the membranes concerned is the glucan layer of the cell wall[5]. Treatment with crop juice of *Helix pomatia*[6], which is known to attack this glucan[7], at a final dilution of 1 : 10, liberated practically all the invertase (125 out of 130 units) from a sample of ethyl acetate-treated material in 8 hr. at 20° C. It has been suggested that invertase must lie near the surface of the yeast cell[3], and so it is possible that it lies between the glucan layer and a protein-containing layer[5]. This might explain the liberation of invertase by the action of papain[1].

It is unlikely that invertase is solubilized by autolytic processes during the ethyl acetate treatment, because the crushing of washed samples of living baker's yeast liberates a large proportion of the invertase in a water-soluble form. Further, on treatment with 0·1 volume of undiluted snail crop juice at room temperature some 50 per cent of the invertase of a sample of living yeast was liberated in 10 hr., while at least 90 per cent of the cells remained viable.

The preparations treated with ethyl acetate retain the outward shape of yeast cells but have obviously lost a great deal of their contents. After crushing, many of the cells show gross destruction, and, on prolonged treatment with snail digestive juice, holes appear in the cell walls. However, it would seem that often quite minor damage is sufficient to set the invertase free. Myrbäck's ethyl acetate-treated preparations might therefore provide a useful and sensitive system for the investigation of the nature of the yeast cell wall.

Two of us (E. E. B. and J. S. D. B.) wish to thank the Czechoslovak Academy of Sciences and Academician I. Málek, director of the Institute, for most generous hospitality which made our participation in this work possible.

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Critical Effect of Oxygen Tension on Rate of Growth of Animal Cells in Continuous Suspended Culture

ITS relevance to current animal virus and cell culture work prompts us to report the feasibility of and requirements for continuous culture of cells in suspension; full details will be given elsewhere.

Medium was pumped at a known rate from a reservoir to a culture vessel kept at 37° C. (20-l. 'Pyrex' aspirators), which overflowed at a constant level into a cooled receiver and was harvested once weekly. Culture vessel and receiver were gassed with mixed carbon dioxide, oxygen and nitrogen and magnetically stirred. Mechanical reliability was essential, as small breakdowns were rapidly lethal. The medium, a modified Earle's saline plus lactalbumen hydrolysate, amino-acids, yeast extract, vitamins, horse and calf serum, contained most components at their highest non-toxic level; these levels are probably not vital for continuous culture except for glucose (6–8 gm./l.). The limiting cell-density was probably not reached, but growth was very rapid under optimal conditions (defined below). Varying the gas-phase carbon dioxide and including bicarbonate kept the pH neutral; a transformed embryo rabbit kidney cell line[1] was used. The system was not self-balancing (not a 'chemostat'), as limitation of medium did not much restrict growth without inducing a sometimes irreversible lag. Since 'steady state' therefore rarely occurred and since synchrony was also possible, growth-rates were not known precisely; they were recorded as 'percentage increase/24 hr.', based on the culture vessel content of a given day. Cells were counted and medium flow-rate, gas-phase carbon dioxide and oxygen levels adjusted daily to control *p*H, cell density and growth-rate. Medium changes were not needed, flow-rate being generally matched with growth-rate; carbon dioxide was 2–5 per cent and oxygen was 5–24 per cent (v/v), cell-density was 5–20 × 10^5 ml., and *p*H was roughly 6·9–7·2.

This system produced in four months continuous medium flow an average of 10^9 (2 gm. wet weight) cells/day in 1 l. of medium from a constant culture volume of 1·5 l. (Fig. 1). The mean doubling time was 25 hr., and sometimes 16 hr. or less. Continuous growth was more efficient and less troublesome than batch culture, in which the narrow optimal ranges of animal cells were soon exceeded. The cells were used for agar-suspension plaque assay[2] and suspension growth of polioviruses, making 10^{11} to 10^{12} plaque-forming units per week.

Unexpectedly, cell growth-rate was very dependent on oxygen levels. The gas mixtures bathing tissue cultures have hitherto had little attention, air (20 per cent v/v oxygen) or 5 per cent carbon dioxide-in-air (19 per cent oxygen) generally sufficing. We find that 20 per cent oxygen and above is relatively inhibitory, and once during a steady state a small drop (from 19 to 17 per cent oxygen) increased the growth-rate by 50 per cent. On another similar occasion, a small increase (from 22 to 24 per cent) halved the growth-rate, while in other experiments 25–30 per cent oxygen was rapidly cytocidal. Since the important factor is the liquid-phase oxygen level or equivalent redox potential, the gas-phase oxygen level for optimal growth at high cell density depends on rates of agitation, oxygen exchange across the surface and oxygen uptake/cell, surface area and depth of culture and cell density. Thus apparent doubling times were 24 hr. or less with oxygen-levels from 14 to 22 per cent (other conditions being constant), but cell densities allowing such optimal growth were always higher at higher oxygen-levels (Table 1). Growth-rates and cell densities were cyclic (Fig. 1). Starting with slight excess of oxygen, a slight rise in cell density decreased liquid-phase oxygen-levels, and growth-rate rose. Cell density also rose, presumably passing through optimal to hypoxic levels of oxygen, when the *p*H fell and growth almost stopped; this resembled a lag, as optimal conditions did not at once restore growth-rate.

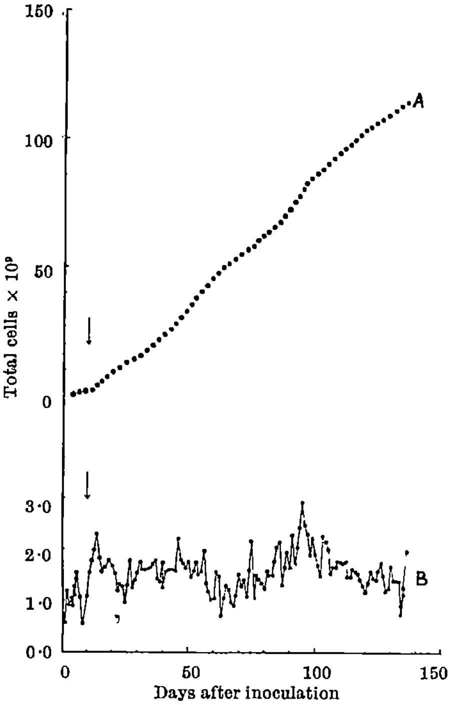

Fig. 1. Continuous growth of animal cells in suspension: *A*, cumulative production; *B*, culture vessel content. The medium was not varied and *p*H was 6·9–7·2; oxygen levels were often varied. Arrows indicate time when continuous flow started

Table 1. MEAN GAS-PHASE OXYGEN AND CULTURE-VESSEL CELL DENSITIES (SEE FIG. 1) WHEN THE CELL INCREASE/24 HR. EXCEEDED 87 PER CENT (PROBABLE MEAN DOUBLING TIMES OF 24 HR. OR LESS)

Percentage oxygen	14	16	16·5	17	18	20	22
Cells/ml. × 10^5	7·8	8·3	10·0	11·3	12·6	13·4	18·0

We conclude that liquid-phase oxygen-levels for fastest growth of these cells is much less than air (and even 14 per cent oxygen) equilibrium values; this has interesting implications for the usual stationary cultures.

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Effect of Oxytocin Administration on Respiration of Lactating Mammary Gland Tissues in Rats

THE participation of the hypothalamus and the posterior lobe of the pituitary in milk ejection is well known. On the other hand, the importance of the suckling stimulus in maintaining the secretion of milk[1], suggested that the hypothalamus and the posterior lobe of the pituitary played some part in controlling the secretion of anterior pituitary galactopoietic hormones.

Recently, Benson and Folley[2] reported that the administration of oxytocin to a lactating rat retarded the mammary involution which occurred after weaning, and suggested the possible part which oxytocin plays in the release of prolactin and other lactogenic and galactopoietic hormones from the anterior pituitary gland. Since Benson and Folley obtained their results by a histological method and discussed the problem from this point of view, it is of interest to use a biochemical method for comparison. Therefore, as an indicator of the activity of the gland, the respiration and rate of production of lactic acid by the tissue slices were employed. The following experiments were carried out:

Table 1. EFFECTS OF OXYTOCIN ADMINISTRATION ON RESPIRATION AND LACTIC ACID PRODUCTION OF RAT MAMMARY GLAND TISSUES

Group	Respiratory quotient	$Q(O_2)$ (μl./mgm. dry wt. of tissue/hr.	Lactic acid produced (μgm./mgm. dry wt. of tissue/hr.)
Oxytocin 1·0 I.U. treated	(*a*) 0·92±0·04* (5)	7·15±3·66 (5)	6·71±4·06 (5)
Oxytocin 2·0 I.U. treated	(*b*) 0·92±0·05 (4)	7·08±3·03 (4)	4·97±2·57 (3)
Intact weaning control	(*c*) 0·94±0·03 (6)	6·11±1·17 (6)	5·58±2·26 (6)
Normal control	(*d*) 1·32±0·09 (4)	14·81±3·46 (4)	2·41±0·34 (3)

Figures in parenthesis represent the number of animals. * 95 per cent fiducial limits. *a* and *b* are not significantly different from *c* ($P < 0·01$); *a*, *b* and *c* are significantly different from *d* ($P > 0·2$).

Nineteen Wistar strain female rats in the first lactation, weighing 160–190 gm., were used. Litters were reduced to six on the first day of lactation, three of each sex being kept whenever possible. They were weaned on the twelfth day of lactation. Oxytocin (1·0 and 2·0 I.U. 'Pituitan': Dainippon Zoki Lab., Osaka) diluted in 0·5 ml. of distilled water, was injected intraperitoneally to nine mothers three times a day, beginning on the afternoon of the weaning day. 3 days after weaning (fifteenth day of lactation and 30 min. after the last injection), the animals were killed by decapitation. Six rats kept intact for 3 days after weaning, which occurred on the twelfth day of lactation (intact weaning control), and four rats on the fifteenth day of lactation (normal control), were used as controls.

The respiratory quotient and oxygen consumption of tissue slices from the mammary glands of these animals were measured manometrically with special flasks[3]. Incubations were carried out in a Krebs–Ringer phosphate solution (*p*H 7·4) containing 0·3 per cent glucose, with a 100 per cent oxygen gas phase—for 2 hr. at 37° C. The amount of lactic acid in the medium was determined chemically[4] after the incubation, and was expressed in terms of μgm./hr./mgm. final dry weight of the slices.

A steep decrease in the respiratory quotient and $-Q(O_2)$ value resulted from the weaning, the normal control tissue slices retaining high values. The rate of production of lactic acid increased after weaning, but remained low in the normal controls. These changes were not affected by oxytocin (Table 1). Vaginal cornification was observed within 2 or 3 days after weaning in both the oxytocin-treated and intact weaning control groups.

During the experimental period (3 days), the alveoli of the mammary glands of both the oxytocin-treated groups and the weaning control group were abundantly filled with milk, and histologically there was no evidence of involution. This observation was consistent with that of Benson and Folley[2] for the mammary gland 6 days after weaning.

The diminution of the respiratory quotient and the recurrence of œstrus may indicate the ineffectiveness of oxytocin on the galactopoiesis of mammary glands and on the maintenance of luteal activity in the ovaries. (This activity of oxytocin was reported by Desclin[5].) Nevertheless, we must take into consideration the results of Cross and Silver[6], who pointed out the importance of engorgement as a cause of the involution taking place after weaning. This suggests that, even if oxytocin has a galactopoietic effect, engorgement may overcome it.

In order to determine the essential role of oxytocin in galactopoiesis, the effects of engorgement of the mammary gland must be eliminated. The experiment, furthermore, must be carried out under conditions which suppress the suckling stimuli completely, since these stimuli are considered to reach the hypothalamus and to cause not only the release of oxytocin from the posterior lobe of pituitary, but also that of the galactopoietic hormones from the anterior lobe. Studies on this problem are now in progress.

After this communication had been sent to *Nature*, we were informed by Dr. A. T. Cowie, of the National Institute for Research in Dairying, Reading, England, that similar results had been obtained independently by Dr. M. L. McNaught[7]. She reported that, in rats, no significant differences in the respiratory activity *in vitro* of mammary gland slices were found between a group receiving 1 I.U. of oxytocin during the 12 hr. after removal of the litter, and a group receiving no oxytocin. She also discussed the effect of accumulation of milk.

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Diuretic Activity of Chlorothiazide Derivatives

CHLOROTHIAZIDE (6-chloro-7-sulphamyl-1,2,4-benzothiadiazine-1,1-dioxide) is not only a very active diuretic drug, but it can also relieve high blood pressure in many patients. This compound has an inhibitory action on carbonic anhydrase, like N-acetylamino-sulphamyl-thiadiazole, and in addition it causes a diuresis not unlike that observed with organic mercurial compounds[1,2], resulting in increased excretion of sodium salts and of water. It seemed interesting to us to analyse the structural conditions necessary for a diuretic activity and, especially, what influence can be attributed to the sulphamyl-group.

1,2,4-benzothiadiazine-1,1-dioxide (Table 1, *a*) has no diuretic activity. The introduction of a sulphamyl-group (Table 1, *b*) gives barely active compound. Therefore, the activity is not mainly due to the sulphamyl-group. Further, ring-closure to thiadiazindioxide is not necessary for diuretic activity, since it is known[3] that 4-amino-6-chlorobenzene-1,3-disulphonamide and its N-acyl-compounds have a high activity.

We found that chlorine cannot be omitted in these compounds (Table 1, *c*), and that it cannot be replaced by an amino-group (Table 1, *d*). Substitution of the sulphamyl-group by alkylation should result in an inactive compound, since this group is responsible for the anti-enzymic effect. It is known[4] that N-alkyl-chlorothiazides have no diuretic activity, but to our great surprise we found a highly active and considerably less toxic compound in 4-amino-6-

Table 1

	Compound	Melting point (deg. C.)	Activity*
a	1,2,4-benzothiadiazine-1,1-dioxide	219–220	1·46
b	7-sulphamyl-1,2,4-benzothiadiazine-1,1-dioxide	319–320	1·34
c	4-amino-benzene-1,3-disulphonamide	232	1·24
d	4,6-diamino-benzene-1,3-disulphonamide	253	0·62
e	4-amino-6-chloro-benzene-1,3-disulphonmethylamide	182	2·48
f	4-amino-6-chloro-benzene-1,3-disulphonallylamide	132	1·64
g	4-amino-6-chloro-benzene-1,3-disulphonbutylamide	97	1·79
h	4-amino-6-chloro-benzene-1,3-disulphondimethylamide	184	1·99
i	4-amino-6-chloro-benzene-1,3-disulphonmorpholinamide	158	0·82
j	4-amino-6-chloro-benzene-1,3-disulphon*cyclo*hexylamide	189	1·19

* Activity: $\frac{\text{Urinary excretion of treated animals}}{\text{Urinary excretion of untreated animals}}$ (ref. 5)

chloro-benzene-1,3-disulphonmethylamide (Table 1, *e*). Therefore, a free sulphonamide group is definitely not necessary for diuretic activity.

Activity decreases rapidly with increasing molecular weight of the alkyl-group (Table 1, *f* and *g*). The dimethyl compound (Table 1, *h*) still has activity and the morpholine compound slight activity, but the cyclohexyl-compound (Table 1, *i* and *j*) is inactive.

Further particulars, especially the pharmacological properties of the compound of Table 1, *e* will be described elsewhere.

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Lipolysis in the Rumen

REISER[1], and more recently Shorland *et al.*[2], reported experiments in which rumen contents of sheep were incubated *in vitro* with linseed oil and with oleic, linoleic and linolenic acids. These experiments, and others using the living animal[3–5], demonstrated that hydrogenation of double bonds of unsaturated fatty acids occurred and that this was effected by the rumen micro-organisms.

We have done experiments in which triglycerides in the form of linseed oil and tung oil were incubated with the rumen contents of sheep (1·0 gm. per 100 ml. rumen contents) in a manner similar to that described by Shorland *et al.*[2]. Not only did hydrogenation occur as indicated by a considerable fall in the iodine value of the lipid, but it was also found that more than 75 per cent of the total lipid recovered at the end of the incubation was in the form of free higher fatty acids. In 'blanks' to which no oil was added, free higher fatty acids represented 50–60 per cent of the total lipid present. Rumen contents obtained from animals fed on rations containing hay and either potato starch and mixed concentrates (including fish meal) or flaked maize, maize meal, groundnut meal and oats gave similar results.

That the lipolysis is the result of enzyme action was demonstrated by incubating linseed oil (iodine value, 181·3) with rumen contents obtained from a fistulated sheep 4 hr. after the last feed of hay and mixed concentrates and with the same rumen contents which had been previously heated in a boiling water-bath. The results of one such experiment are given in Table 1. After allowing for the difference between the amounts of free fatty acids in flasks 2 and 4, it is calculated that about 60 per cent of the esterified fatty acid residues were liberated from the oil in flask 2. No lipolysis was observed in flask 4, the slight difference between the amounts of fatty acids recovered from flasks 3 and 4 being due to the traces of free acid originally present in the linseed oil. Noteworthy is the low iodine value of the fatty acids derived from rumen contents alone; calculation gives the iodine value of the acids resulting from lipolysis in flask 2 as 121·4, which represents a decrease of about 70 units compared with the iodine value of the acids present initially in glyceride combination.

Table 1. AMOUNTS AND IODINE VALUES OF FREE HIGHER FATTY ACIDS FOUND AFTER INCUBATING SHEEP RUMEN CONTENTS, WITH AND WITHOUT THE ADDITION OF LINSEED OIL, AT 37° C. FOR 24 HR. (Each flask contained 100 ml. rumen contents)

Flask	Treatment before incubation	Addition	Free fatty acids	
			Weight (mgm.)	Iodine value
1	None.	None	245	22·8
2	None	Linseed oil (1·00 gm.)	859	97·4
3	Heated at 90° C. for 1 hr.	None	236	31·6
4	Heated at 90° C. for 1 hr.	Linseed oil (1·00 gm.)	268	44·7

Extensive lipolysis of ingested glycerides in the rumen of the intact animal was found on examination of the contents of the alimentary tract of a sheep which had been fed for several months on a diet consisting largely of hay, linseed meal and maize to which 40 gm. of linseed oil were added daily. At slaughter, 7 hr. after the last feed, 80–90 per cent of the lipid in the rumen, abomasum and upper part of the small intestine was in the form of free higher fatty acids of iodine value about 70. In the lower part of the small intestine the free fatty acids comprised 68 per cent of the total lipids and had an iodine value of 48.

Saliva is one of the main constituents of the liquid phase of rumen contents, but no lipolytic activity towards linseed oil could be demonstrated in samples of adult sheep saliva which were made available to us by our colleague Dr. R. N. B. Kay. It is therefore presumed that micro-organisms are responsible for the production of a lipase in the rumen; in this connexion it is of interest to note that Johns[6] has already shown that glycerol is fermented slowly in the sheep's rumen to yield propionic acid.

Our preliminary observations indicate that, in the ruminant, dietary triglycerides reach the small intestine largely in the form of free fatty acids, of which the unsaturated components have been modified by hydrogenation. This is in marked contrast to the digestion of lipids in adult monogastric animals in which little or no lipolysis occurs before triglycerides of long-chain fatty acids reach the intestine

Further studies, both biochemical and bacteriological, on the fate of ingested lipids in the alimentary tract of ruminant animals are in progress.

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Metabolism of 16-Oxoœstrone by Human Liver Slices *in vitro*

Layne and Marrian[1] recently reported the isolation of 16β-hydroxyœstrone from the urine of pregnant women, and Brown, Fishman and Gallagher[2] detected the same compound by reverse isotope dilution in the urine of a human subject after the administration of œstradiol-17β-16^{14}-C. In the course of our own studies on the metabolism of œstrogens *in vitro*, 16β-hydroxyœstrone has been found after incubation of 16-oxoœstrone with normal human liver slices. In addition, five other phenolic steroids have been identified as metabolites of 16-oxoœstrone.

In a typical experiment, 200 mgm. of liver slices were incubated with 100 μgm. of 16-oxoœstrone in 5 ml. Krebs phosphate saline for 60 min. at 37° C. The incubation medium and the tissue were extracted twice with equal volumes of an ether-chloroform mixture (3 : 1 v/v). In order to separate 16-oxoœstrone from the higher polar transformation products, the extracts were subjected to paper chromatography in the system benzene/methanol/water (100 : 55 : 45). The material more polar than 16-oxoœstrone was eluted and resubjected to chromatography in the system formamide/chloroform. After spraying the paper with Folin and Ciocalteu's reagent[3] eight substances (I–VIII) were detected, six of which had the same mobility and showed the same absorption curves in the Kober reaction as pure œstriol (II), 16-epi-œstriol (IV), 17-epi-œstriol (V), 16β-hydroxyœstrone (VI), 16-oxo-œstradiol-17β (VII) and 16α-hydroxyœstrone (VIII). For further identification, the metabolites were coupled with fast black salt *K* to make azo derivatives, followed by paper chromatography in the system toluene/petroleum ether/ethanol/water (200 : 100 : 30 : 70)[4]. With substances II and IV–VIII well-defined spots were formed, identical in all ways with spots produced by parallel runs of (R_F values in brackets) œstriol (0·07), 16-epi-œstriol (0·46), 17-epi-œstriol (0·32), 16β-hydroxyœstrone (0·56), 16-oxoœstradiol-17β (0·77) and 16α-hydroxyœstrone (0·60), respectively. In the sulphuric acid/water reaction[5] the absorption spectra of substances II, IV, V, VII and VIII were identical with those of (maxima in brackets) œstriol (282 ; 458 mμ), 16-epi-œstriol (290 ; 457 mμ), 17-epi-œstriol (286; 456 mμ), 16-oxoœstradiol-17β (272 ; 503 mμ) and 16α-hydroxyœstrone (270 ; 507 mμ) respectively. When substance VI was reduced with sodium borohydride, a compound was formed which was in every respect indistinguishable from 16-epi-œstriol. Since on reduction of authentic 16β-hydroxyœstrone with sodium borohydride only 16-epi-œstriol is formed while 16-oxoœstradiol-17β is reduced to 16-epi-œstrol as well as œstriol, it is concluded that substance VI is identical with 16β-hydroxyœstrone.

The quantitative examination of the extracts revealed that 16-oxoœstrone was metabolized very rapidly by human liver slices. The main metabolites were 16-oxoœstradiol-17β and 16β-hydroxyœstrone, whereas œstriol and 16-epi-œstriol were formed in smaller amounts. 16α-Hydroxyœstrone and 17-epi-œstriol were minor metabolites. It is interesting that we failed to detect any of the 16- or 17-hydroxy ring *D* ketols after incubation of œstriol, 16-epi-œstriol or 17-epi-œstriol with human liver. These findings and the experiments reported here support the view that the hydroxy ring *D* ketols are mainly derived either from direct hydroxylation[6] or, less probably, from oxidation and subsequent reduction[7] of œstrone rather than from oxidation of the corresponding triols. This concept, however, does not exclude the possibility that, to a small extent (less than 1 per cent), the triols can be oxidized to ring *D* ketols, as has recently be shown by Levitz, Spitzer and Twombly[8].

Full details will be published elsewhere. This investigation was supported in part by research grants from the Government of Nordrhein-Westfalen.

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Pregnanediol in the Urine of the Ewe

The establishment of the relationship between progesterone and 5β-pregnane-3α : 20α-diol by Venning[1] was followed by a number of reports of the isolation of pregnanediol from the urine of other species.

Marker[2] reported that considerable quantities of pregnanediols were present in the urine of pregnant cows, bulls and steers, but Stevenson[3] and Hill[4] were unable to substantiate these findings.

Aparici[5] claimed to have measured large quantities of pregnanediol in the urine of pregnant cows but he did not isolate and characterize the material which he measured. In a recent comprehensive study of the lipid fraction of pregnant cow urine, Klyne and Wright[6] failed to identify any pregnanediol, but in a similar study of pregnant goat urine[7] they found a pregnanediol concentration of 2 mgm. per litre.

As part of an investigation on progesterone metabolism in the ewe, 20 l. of pooled urine from ten pregnant ewes in the fourth month of pregnancy were hydrolysed, extracted by the usual methods, and chromatographed on alumina.

The fraction corresponding to 5β-pregnane 3α : 20α-diol, yielded, after recrystallization from ethanol–water, 35 mgm. of white crystals which melted at 234–236° C. and gave no depression when a mixed melting point was determined with authentic 5β-pregnane 3α : 20α-diol. The infra-red spectra of this material matched that of authentic pregnanediol.

The work was repeated on 10 l. of pregnancy urine collected from other ewes a year later and a similar result was obtained. 10 l. of urine from anœstrous ewes was investigated by similar methods and no trace of pregnanediol was found.

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Ribosyl Transfer between Ribose Nucleotides in the Rat

IN the course of studies on alterations in the rate of catabolism of nucleic acids induced by radiation after total body exposure of rats, evidence has been obtained of the existence of an exchange between the ribosyl residues of purines and pyrimidines and urinary imidazole acetic riboside. The latter riboside has served as a measure of the isotope concentration in the ribose pool of the rat. Hiatt *et al.*[1] have reported recently an application of this 'metabolic trap' to the study of mechanisms by which glucose is metabolized *in vivo*, particularly with respect to the contribution of the glucose-6-phosphate oxidative shunt to the metabolism of glucose. The use of imidazole acetic riboside as a device for trapping ribosyl residues has been made possible by the findings of Tabor and his collaborators[2,3], who have demonstrated that imidazole acetic riboside is one of the major urinary excretion products of imidazole acetic acid.

In a typical experiment, a rat weighing 194 gm. was injected intraperitoneally with 2 μc. of cytidylic acid-^{14}C (uniformly labelled) equivalent to $8 \cdot 5 \times 10^5$ c.p.m. and 8 mgm. of imidazole acetic acid. Urine was collected for 20 hr. thereafter; the rat was killed at the end of the 20-hr. period.

The ribonucleic acid fraction of the liver was isolated as described by Paine *et al.*[4]. The (free) nucleotide fraction soluble in acid was adsorbed on activated charcoal ('Norite' *A*) from the supernatant resulting from treatment with perchloric acid and was then eluted according to the procedure of Cabib *et al.*[5]. The nucleotide polyphosphates thus obtained were converted to their corresponding monophosphates which, in turn, were separated by paper chromatography[6]. The ribonucleic acid fraction was hydrolysed by Schmidt and Thannhauser's method[7] and the resulting nucleotides separated and isolated by Hurlbert and Potter's procedure[8].

The isolation of imidazole acetic acid from urine was accomplished as follows: (*a*) Removal of substances insoluble in 66 per cent aqueous methanol (v/v); (*b*) placing the methanol-soluble fraction on a column of 'Amberlite 120'(H+), removal of glucose and pentoses by washing the column with water, and elution of the riboside with 2 *M* ammonium hydroxide; (*c*) final purification of the effluent fraction containing riboside by means of paper chromatography in two different solvent systems[2]. Imidazole acetic riboside was eluted from the paper strips with methanol. The methanol was distilled off and the riboside concentration was determined quantitatively in an aqueous solution of the residue in terms of periodate consumption[9]. The aqueous washings of the 'Amberlite 120' column were passed through a column of 'Amberlite *IR* 400' (acetate form, 16–50 mesh). Glucose and pentoses were not retained by this column and were isolated from the effluent solution by paper chromatography[10]. After treatment of the paper strips with aniline phthalate, appropriate areas of the chromatograms were eluted with methanolic acetic acid (5 per cent). These eluates were then used for the determination of chemical and isotopic concentrations of the respective carbohydrates.

Details concerning the isolation procedure and chemical determination of the urinary carbohydrates will be published elsewhere. All determinations of radioactivity were carried out with a gas-flow counter using 'infinitely thin' layers of the compounds on polyethylene planchets, 2·5 cm. in diameter. The results are presented in Table 1.

Table 1. INCORPORATION OF CARBON-14 ACTIVITY IN VARIOUS COMPOUNDS RELATED TO THE RIBOSE POOL AFTER INJECTION OF CYTIDYLIC ACID-^{14}C (UNIFORMLY LABELLED)

Source	Compound isolated	Micromolar carbon-14 activity (c.p.m./μM)
Liver	Ribonucleic acid nucleotides	
	Cytidylic acid*	185
	Uridylic acid	120
	Adenylic acid	44
	Guanylic acid	40
	Acid-soluble nucleotides (free)	
	Adenylic acid	30
	Uridylic acid	300
	Glycogen (as glucose)	1
Urine	Imidazole acetic riboside	320
	Ribulose	305
	Xylulose	360
	Glucose	47

* The micromolar carbon-14 activity ratio of cytosine/ribosyl moiety was 0·31.

The following conclusions have been drawn from the results obtained: (1) The findings suggest the occurrence of transfer of ribosyl residues of cytidylic acid to imidazole acetic riboside as well as to free and ribonucleic acid-bound uridylic and adenylic acid in the liver. (2) The micromolar carbon-14 activity of the free urinary pentoses equals approximately that of the ribosyl moiety of imidazole acetic riboside, suggesting that incorporation of carbon-14 into the latter ribosyl moiety has occurred largely by way of phosphorolytic cleavage followed by pentose interconversions. (3) The results indicate that the contribution of cytidylic acid ^{14}C (uniformly labelled) to the labelling of purine nucleotides in the liver, either free or bound to ribonucleic acid, is of minor importance. (4) The low isotope concentration of urinary glucose suggests that the carbon atoms of the ribosyl moiety are probably not in equilibrium with the carbon atoms of glucose.

We are indebted to Dr. H. Tabor for making available some unpublished information regarding imidazole acetic acid and imidazole acetic riboside.

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Selenium and Liver Necrosis in the Hyperthyroid Rat

It is well known that dietary deficiencies can be seriously aggravated by the induction of a hyperthyroid state. Recently it has been shown[1-3] that selenium significantly prolongs the survival-time of rats and prevents the onset of the liver necrosis which follows the ingestion of a diet containing yeast as the only source of protein. This protective effect of selenium resembles that shown by a number of apparently unrelated substances such as methionine, cystin, vitamin E, methylene blue and methylthiouracil, the mode of action of which is not understood. Unpublished observations, made in the course of a systematic investigation into the effects of various hormonal and nutritional stimuli on the course of liver necrosis, had suggested that it might be possible to distinguish between a true protective effect and a 'non-specific', indirect effect of the substances tested by the induction of a hyperthyroid state. Methylthiouracil, for example, which protects the euthyroid weanling rat against the onset of liver necrosis, was ineffective in litter-mates made hyperthyroid by the simultaneous addition of thyroid powder to the diet. A somewhat similar effect was seen if methylene blue was given, in contrast to the persistence of the protective effect obtained if vitamin E was used. In the light of these considerations it was thought of interest to see how the induction of a hyperthyroid state would affect the protective effect of selenium in dietary liver necrosis.

Male litter-mate rats of a strain bred in the Department of Anatomy, Birmingham, were weaned on the twenty-first day of life, the first day of the experiment, and were fed the 'necrogenic yeast diet' of Lindan and Himsworth[4] to which thyroid powder and sodium selenite had been added. The dose of selenium was kept constant at a level of 0·00002 per cent, but the level of thyroid powder was increased from 0·2 per cent (Exp. 1) to 0·3 per cent (Exp. 2) and 0·5 per cent (Exp. 3). All animals were kept in individual cages with raised screen floors, and were allowed to die spontaneously. The survival times and the incidence of liver necrosis are presented in Table 1. It can be seen that the induction of hyperthyroidism significantly accelerated the onset of liver necrosis, but that despite the presence of even a severe hyperthyroid state (Exp. 3), the small amount of selenium given prevented the development of dietary liver necrosis. Although the difference in the survival times of the rats fed the highest amount of thyroid powder with and without selenium was not significant, the absence of liver necrosis was striking. This protective action of selenium, in the presence of varying degrees of hyperthyroidism, is suggestive of a direct effect of selenium, and is best interpreted as the alleviation of a true deficiency. In view of the observations of Bunyan, Edwin and Green[2] on the protective effects of trace elements other than selenium, it would be of interest to see what effect the induction of a hyperthyroid state would have on the action of these trace elements.

Table 1. The Effect of Varying Levels of Thyroid Hormone with and without Selenium on the Survival Time (in days) of Litter-mate Rats fed the 'Neorogenic Yeast Diet'.
(Incidence of liver necrosis in parentheses)

Level of thyroid hormone	No. of animals	Necrogenic diet	Necrogenic diet plus thyroid hormone	Necrogenic diet plus thyroid hormone plus sodium selenite (0·00002 per cent)
Exp. 1: 0·2 per cent	7	40·4 ± 5·42 (7/7)	25·0 ± 1·02 (7/7)	59·4 ± 9·48 (1/7)
Exp. 2: 0·3 per cent	7	29·3 ± 1·25 (7/7)	19·6 ± 0·68 (7/7)	33·9 ± 3·54 (0/7)
Exp. 3: 0·5 per cent	8	23·3 ± 2·33 (8/8)	16·7 ± 0·50 (8/8)	20·5 ± 2·19 (0/8)

Another point of interest is the effect of supplements of selenium on the course of the hyperthyroid state itself. Although the addition of thyroid powder to the diet significantly ($P < 0.001$) hastened the onset of liver necrosis in all the animals, increasing the dose of thyroid powder from 0·2 to 0·3 or 0·5 per cent had no significant effect on the survival times if each group was compared with the untreated litter-mate controls. (The spontaneous decrease in the survival times of the untreated controls of Exps. 1–3, seen in Table 1, is purely accidental.) This is in contrast to the obvious decrease in survival times found with increasing doses of thyroid hormone, if selenium is given in the diet as well. By comparison with the litter-mates given thyroid only, the regression was significant at the 5 per cent level using a 'two-sided' test. This observation again suggests that selenium acts by alleviating a dietary deficiency, and underlines the caution which is indicated if the effects of the pure, uncomplicated hyperthyroid state are to be clearly assessed.

I should like to thank Dr. D. Darlington for the statistical analysis of the data.

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Utilization of the Carboxyl Group of Glycine for the Synthesis of the Amino-Acids of Silk by *Bombyx mori*

WHEN fasting and ready to spin their cocoons, five silkworms were each injected with 112 μgm. (2·1 μc.) of glycine-1-^{14}C.

Fibroin was isolated from the cocoons by the method described by Dunn *et al.*[1]. The four amino-acids—tyrosine, glycine, alanine and serine—were then isolated from the hydrolysed fibroin, using a modification of Stein and Moore's procedure[2]: the hydrolysed fibroin was freed of excess hydrochloric acid by repeated evaporation and then by percolating through a bed of 'Amberlite' *IR* 120 (H^+). The amino-acids adsorbed on the resin were eluted with 3 *N* ammonia, which was then evaporated *in vacuo*. At this stage, the tyrosine was removed by filtration and purified by crystallization and finally by chromatography on a starch column, with butanol/water as solvent[3]. Tyrosine was completely radio-inactive. Glycine was precipitated as glycine nitronaphthalene sulphonate, alanine as azobenzene-*p*-sulphonate and serine as *p*-hydroxyazobenzene-*p*-sulphonate. The amino-acids were obtained by passing the sulphonates through an 'Amberlite' *IR* 120 (H^+) column and then eluting with 3 *N* ammonia. They were crystallized several times in water–ethanol–diethylether.

The specific activities of the sulphonates and of the derived amino-acids remained constant throughout the crystallizations. The chemical purity of each amino-acid was checked by Kjeldahl nitrogen analysis and by paper chromatography in butanol/hydrochloric acid and in phenol/water. They were then oxidized and converted to barium carbonate. The radioactivity measurements were performed with a thin mica-window Geiger counter on barium carbonate deposits. Each amino-acid was decarboxylated with ninhydrin[4]. The carbon dioxide evolved was trapped in sodium hydroxide solution and converted to barium carbonate. The radioactivities of the isolated amino-acids and of their carboxyl groups, corrected for background and self-absorption[3], are summarized in Table 1.

Table 1

	Specific activities		Total activity per cocoon (counts/min.)
	Amino-acid (counts/min./mmole)	Carboxyl group (counts/min./m.equiv.)	
Injected glycine	$2 \cdot 7 \times 10^8$	$2 \cdot 7 \times 10^8$	
Isolated glycine	196,000	196,000	81,500
Isolated serine	65,700	63,600	7,500
Isolated alanine	18,200	18,600	5,400
Isolated tyrosine	0	0	0
			94,400

Total activity injected per worm, 400,000 counts/min.

From these results, one can conclude that: (1) One quarter of the total activity injected appeared in silk fibroin. (2) The injected glycine was found diluted about one thousand-fold in the silk, which was most probably not uniformly labelled. (3) Direct conversion of glycine to serine keeping the label in the C-1 position occurs in the silkworm. It is probably the result of the addition of a one-carbon unit as shown in mammals, birds and micro-organisms. (4) There is also a conversion of glycine to alanine which might proceed through serine and pyruvic acid. Whatever the steps of this transformation are, the reactions involved must introduce the C-1 of glycine exclusively into the carboxyl group of alanine. (5) Tyrosine has not incorporated any radioactivity from glycine-^{14}C, whereas in a previous communication we have shown a direct conversion of phenylalanine to tyrosine[6]. This seems to indicate that the phenylalanine-tyrosine pair is essential to the silkworm.

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Utilization of Formate for the Biosynthesis of Glycine Carbon-1 and -2 in *Bombyx mori*

JUST prior to spinning their cocoons, each of twenty silkworms was injected with 1·7 mgm. (25 μc.) of formate labelled with carbon-14. The fibroin, isolated by the method of Dunn *et* al.[1], was hydrolysed and the glycine isolated as nitronaphthalene sulphonate. This salt was recrystallized several times, then dissociated on a 'Dowex' 50 column; free glycine was eluted with 3 *N* ammonia and crystallized in water/ethanol/diethylether. Its chemical purity was checked by paper chromatography in two different solvents (phenol/*iso*propyl alcohol/water and butanol/acetic acid/water). The specific radioactivities of the nitronaphthalene sulphonate and of the free glycine remained constant throughout the recrystallizations.

The isolated glycine was decarboxylated[2]; C-1 was isolated as barium carbonate and C-2 as formaldimedone. The specific activities of the isolated glycine and of its two carbons are shown in Table 1; all determinations were performed with a thin mica-window Geiger counter on barium carbonate deposits (glycine and formaldimedone were oxidized and converted to barium carbonate before the assays) and the results corrected for background and self-absorption.

The degradation procedure was checked on synthetic glycine-1-^{14}C and glycine-2-^{14}C (Table 1).

It can be concluded that formate carbon is utilized for the synthesis of glycine C-1 and C-2 in *Bombyx mori.* 1·5 per cent of the injected radioactivity appeared in the fibroin glycine, while 2 per cent was found in fibroin serine which had a specific activity about six times greater than glycine.

Several biochemical pathways, known in other organisms, can be suggested to explain these results. Further work, namely the analysis of the distribution

Table 1. SPECIFIC ACTIVITIES
(counts/min./mmole or m.equiv.)

	Isolated	1-^{14}C	2-^{14}C
Glycine	68,400	33,600	280,000
C-1	20,300	33,800	158
C-2	43,500	42	277,000

of carbon-14 in serine and alanine isolated from the silk fibroin, can help us to decide which of these routes is the most important in *Bombyx mori*. We already know that the administration of glycine-1-^{14}C is not followed by a redistribution of the labelled carbon between the two carbons (see preceding communication).

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Cellulolytic Activity of Phytopathogenic Bacteria

As the great majority of phytopathogenic bacteria are extracellular parasites occupying chiefly the vessels and the intercellular spaces, and causing vascular diseases, soft-rots, spot diseases, etc., the ability to decompose the surrounding walls composed of pectin and cellulose is supposed to be an important factor controlling the destruction and/or enlargement of the tissues attacked. Although Husain and Kelman[1] reported the presence of cellulase in diseased tomato tissues infected by *Pseudomonas solanacearum*, our knowledge of the cellulolytic enzymes is poor in comparison with that in the field of pectolytic enzyme studies of plant pathogens.

We have sought evidence *in vitro* as to whether cellulolytic enzymes are produced by other phytopathogenic bacteria. Bacterial species or isolates used were from our collections in Japan. For the recognition of cellulolytic enzymes carboxymethylcellulose gel medium was used as stab cultures and observed periodically for three weeks at an incubation temperature of 30° C. When the enzymes were produced, stratiform liquefaction of the gel followed the growth of bacterial species inoculated. The carboxylmethylcellulose gel medium was prepared as follows: 2 per cent of carboxymethylcellulose (Koso Chem. Co., Ltd., Tokyo) was dissolved in hot basal medium (70° C.) such as bouillon, potato decoction, synthetic solution *A* (ammonium dihydrogen phosphate, 1 gm.; potassium chloride, 0·2 gm.; magnesium sulphate, 0·2 gm.; distilled water, 1 l.); synthetic solution *B* (ammonium nitrate, 1 gm.; potassium hydrogen phosphate, 1 gm.; magnesium sulphate, 0·2 gm.; distilled water, 1 l.); or synthetic solution *C* (Uschinsky's solution without glycerol), then heated almost to boiling point and stirred sufficiently to form a homologous gel. The mixtures were placed in tubes and autoclaved at 15 lb./in.^{2} for 10 min. Tests were made with 13 species of *Pseudomonas*, 7 species of *Xanthomonas*, 2 species of *Erwinia*, 1 species of *Agrobacterium* and *Corynebacterium*, including various isolates of each species.

Prompt liquefaction of the gel was observed in bouillon and potato decoction cultures after 3–5 days, while in synthetic media the gel was liquefied very slowly and some isolates showed only partial liquefaction even after three weeks. The liquefying species or isolates grew well throughout the dissolved layers of gel. Growth of the non-liquefying ones was moderate on the gel surface in bouillon and potato decoction, but feeble or absent in synthetic media.

The results, obtained from potato-decoction gel cultures, showed that cellulolytic enzymes are produced from *Ps. panici* (syn. *Ps. setariae*), *Ps. solanacearum*, *Xanthomonas campestris*, *X. citri*, *X. nigromaculans*, *X. oryzae*, *X. pisi* (a new species, not reported), *X. pruni*, *X. vesicatoria*, *Erwinia carotovora* (including *E. aroideae* as a synonym), *E. milletiae*, *Corynebacterium sepedonicum*, but not from *Ps. aeruginosa*, *Ps. andropogoni*, *Ps. cichorii*, *Ps. eriobotryae*, *Ps. iridicola*, *Ps. maculicola*, *Ps. marginalis*, *Ps. marginata*, *Ps. phaseolicola*, *Ps. syringae*, *Ps. tabaci*, *Ps. theae* and *Agrobacterium tumefaciens*.

In the case of *X. oryzae*, *E. carotovora* and *Ps. solanacearum*, the rapidity of liquefaction varied with the kinds of isolates used.

The pathological significance and biochemical characteristics of the cellulolytic enzyme produced by these bacteria will be discussed elsewhere.

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The Kidney and Erythropoiesis

IT has been pointed out[1,2] that, in the dog, bilateral nephrectomy abolishes erythropoiesis, and it was suggested that the kidney produces a factor stimulating red blood cell formation. The experimental result did not definitely exclude retention of some toxic substance that inhibits the erythropoiesis, since the nephrectomized animals were still uræmic (blood urea level at about 300 mgm. per cent) despite peritoneal dialysis.

In further experiments an attempt was made to dissociate a toxic effect from the lack of some erythropoietic factor of renal origin. Thus, erythropoiesis was studied in a group of eight dogs submitted to bilateral ureter ligation. This group was compared with one group of seven intact and one group of eight bilaterally nephrectomized animals.

Bone-marrow samples were examined every other day before and after surgery. 72 hr. after surgery, 5 μc. of iron-59, previously incubated in 20 ml. plasma, were given intravenously. The uptake of iron-59 into erythrocytes was measured in eight dogs during the three following days.

Five dogs lived long enough to allow studies of the maximal incorporation of iron-59. The dogs with ligated ureters as well as the nephrectomized ones refused food, and were given two or three daily peritoneal dialyses, thus reaching similar levels of toxic retention and malnutrition.

Despite these conditions, the following experiments show that erythropoiesis is almost normal in animals with ureteral ligation, showing that the absence of a kidney-factor is responsible for the impaired erythropoiesis in nephrectomized dogs.

The disappearance curves of iron-59 from the plasma are similar in normal dogs (39–153 min.) and in those with ligated ureters (64–171 min.). The average time at which half the radioactivity initially present has disappeared ($T/2$) is 299 min. in the nephrectomized, 89 in the normal animals and 96 in those with ligated ureters.

The rate of turnover of plasma iron is higher in animals with ligated ureters (0·25–0·85 mgm./kgm./day; mean, 0·48) than in nephrectomized ones

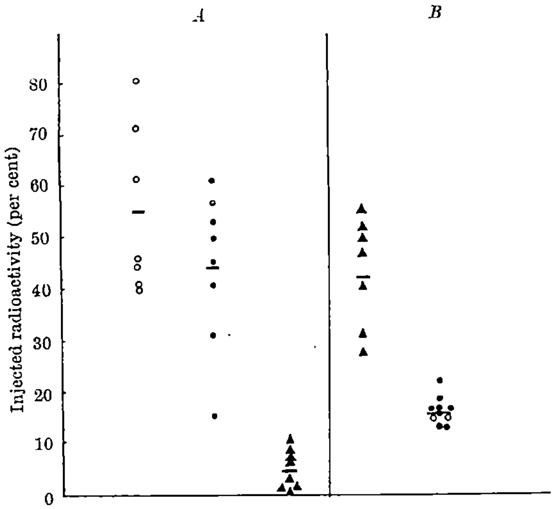

Fig. 1. (*A*) Uptake of iron-59 into erythrocytes. ○, Normal dogs 72 hr. after injection of iron-59; ●, dogs with ligated ureters 72 hr. after injection of iron-59; ▲, maximal uptake in nephrectomized dogs; —, mean. (*B*) Uptake of iron-59 into liver. ○, Normal dogs; ●, dogs with ligated ureters; ▲, nephrectomized dogs; —, mean

(0·09–0·49 mgm./kgm. day; mean, 0·24); the differences observed are statistically significant ($P < 0 \cdot 01$). It is slightly lower than in normal animals (0·25–0·92 mgm./kgm./day; mean 0·64) but these differences are not significant ($0 \cdot 1 < P < 0 \cdot 2$).

The incorporation of iron-59 into red cells three days after injection of the isotope is almost the same in dogs with ligated ureters (15·6–60·9 per cent; mean, 44·1) as in normal animals (40–80·8 per cent; mean, 55·3), while it is less than 12 per cent in the nephrectomized dogs, 8 and even 10 days after the isotope administration. Maximal incorporation averages about 70 per cent in the normal and 61 per cent in the five dogs with ligated ureters (Figs. 1 and 2).

Our observations included an estimation of erythropoiesis by post-mortem measurements of radioactivity in the liver (Fig. 2). This radioactivity varies from 27 to 55 per cent (mean, 43·3 per cent) of the injected tracer dose in the group of seven bilaterally nephrectomized dogs and from 13 to 22 per cent (mean, 16·1 per cent) in the control group of dogs with ligated ureters and in two normal dogs. This suggests that in the controls iron-59 is chiefly deposited in erythropoietic organs. We also regard as noteworthy the persistence of erythroblasts in the bone-marrow of dogs with ligated ureters, since these elements disappear three days after bilateral nephrectomy.

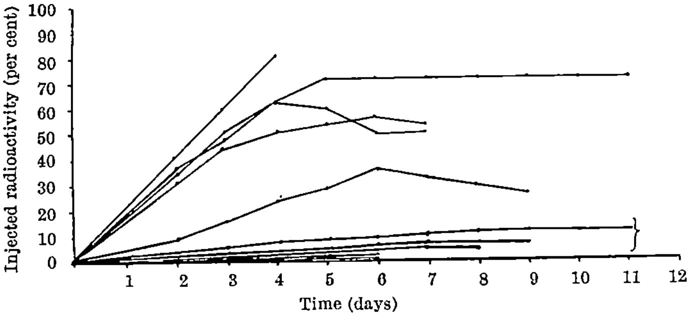

Fig. 2. Uptake of iron-59 into erythrocytes. The curves in the bracket are for nephrectomized dogs, the others for dogs with ligated ureters

These observations lead to the conclusion that the kidney produces an erythropoietic-stimulating factor, or transforms some precursor into an active agent. Besides this, it was shown that retention of toxic products does not impair erythropoiesis.

Our results agree with those of Jacobson[3] working on rats, but diverge from the observations of Mirand and Prentice, who noted an erythropoietic response in anoxic nephrectomized rats[4].

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Effect of Drugs on Conditioning and Habituation to Arousal Stimuli in Animals

Previous studies[1,2] using the feline *encéphale isolé* of Bremer have shown differential effects of certain drugs on the thresholds for electrocortical activation and behavioural arousal from sleep produced by auditory stimulation. In order to confirm and extend these results further experiments were carried out in conscious, chronic cat preparations carrying permanently implanted cortical recording electrodes[3]. For recording purposes these animals were placed in a constant-environment chamber fitted with a one-way glass window. Auditory stimuli were presented from a loudspeaker fitted in a side wall of the chamber, and the threshold for arousal was taken as the intensity of stimulation necessary to bring about abrupt desynchronization of the electrocorticogram and behavioural arousal.

It is clear that in any comparative study of the changes produced by drugs in the behavioural and electrocortical arousal reaction evoked by repeated sensory stimulation, we must take into consideration the normal processes which occur simultaneously. For example, in the present study the thresholds for arousal produced by a given auditory stimulus were not the same in every animal, and in any one animal they tended to fluctuate from day to day. In addition, the thresholds for a particular stimulus, although remaining constant when determined two or three times over a 4-hr. period, tended to increase when the stimulus was continually repeated over a similar period of time.

Habituation of the arousal reaction therefore developed very rapidly in these preparations where minimal intensities of auditory stimulation were employed, and it was found that the thresholds for auditory-induced arousal responses were only constant from approximately the first to the fifth presentation. This does not present a very stable base-line on which to test the effects of incremental doses of drugs. Sharpless and Jasper[4], however, have shown that habituation to a stimulus may be overcome by positive conditioning, and

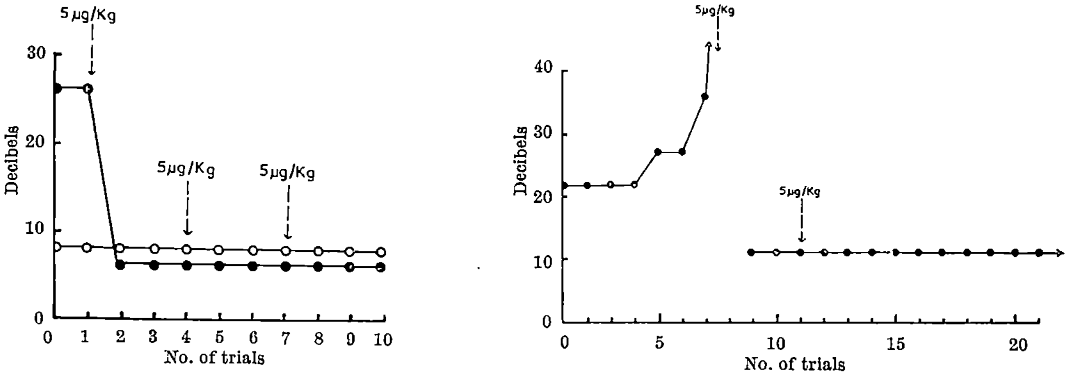

Fig. 1A

Fig. 1B

Fig. 1. *A*, The effect of lysergic acid diethylamide on conditioned and unconditioned auditory-induced arousal responses. *B*, The effect of lysergic acid diethylamide on habituation of the arousal reaction. ●, Threshold for unconditioned arousal; ○, threshold for conditioned arousal

therefore all preparations used in this study were conditioned to arouse upon the presentation of a specific tone. The conditioned response, consisting of both electrocortical desynchronization and behavioural arousal from sleep, was obtained by pairing an electric shock with the particular tone chosen. In doing this it was found that the arousal thresholds remained stable from day to day and the stimulus could be repeatedly presented at short intervals for something like 30–40 trials before extinction took place. It is interesting to note that during the conditioning trials the thresholds for electroencephalographic and behavioural arousal produced by the conditioned stimulus progressively decreased in every animal to a level approaching the threshold of hearing.

In all the experiments carried out with chronic unrestrained preparations the drugs were injected by the intraperitoneal route. Chlorpromazine in doses of 5–10 mgm./kgm. produced a rise in the thresholds for conditioned and unconditioned auditory-induced arousal responses. Following a total dose of 15–20 mgm./kgm., the conditioned as well as the unconditioned arousal response was blocked completely even when the intensity of the stimulus was considerably increased above control levels. At this point visual and tactile stimuli which normally evoked arousal responses failed to do so.

Reserpine also produced an increase in the arousal thresholds. Since this drug appears to have a delayed action incremental doses were not given. Instead, a single dose of 200 or 250 µgm./kgm. was injected and the thresholds then checked every half-hour over a 5-hr. period. The effects of reserpine were very slow to appear, and no significant effect was observed until 1–1½ hr. after the injection, when the thresholds for conditioned and unconditioned auditory-induced arousal showed a slight rise. After 2–3 hr., however, a dissociation of the threshold/time response curves became apparent. The thresholds for the unconditioned response rose progressively until 3½ hr. after the injection arousal produced by the neutral stimulus was blocked completely. On the other hand, the threshold for the conditioned response remained constant or rose a further step but in no case was the conditioned response blocked by reserpine. Moreover, the animal still responded to novel stimuli, which suggests that the blocking of the unconditioned response might be due to habituation.

The effect of lysergic acid diethylamide was tested on conditioned and unconditioned arousal responses. In addition, the animal was also habituated to an auditory stimulus by continued presentation over a short period of time. After an initial dose of 5 µgm./kgm. of lysergic acid diethylamide conditioned arousal responses remained unaffected but the threshold for the unconditioned response fell sharply (Fig. 1*A*). Similarly, the stimulus to which the animal had become habituated now evoked a marked response. The intensity of the stimulus needed to produce this effect was also much lower than the original level (Fig. 1*B*). Following a total dose of 10–15 µgm./kgm. of lysergic acid diethylamide the animal became more responsive to sensory stimulation and remained alert for long periods. The thresholds for arousal, however, did not show any further change.

The arousal value of a sensory stimulus depends upon the significance which is attached to it by the animal. Positive conditioning increases the significance, whereas during habituation there is a loss of significance. In these experiments chlorpromazine appeared to simulate the effects of habituation for a wide range of sensory stimuli, the animal becoming indifferent to stimuli which previously had evoked electrocortical activation and behavioural arousal. In contrast, lysergic acid diethylamide appeared to increase the significance of most sensory stimuli to a level similar to that achieved by positive conditioning for any given stimulus. The fact that both lysergic acid diethylamide and chlorpromazine produced no marked effect on the thresholds for arousal evoked by direct stimulation of the brain stem reticular formation[2], and yet have an effect on auditory-induced arousal responses, emphasizes the importance of the neural mechanisms regulating the inflow of sensory information in relation to the action of these drugs.

The blocking of the unconditioned arousal responses following reserpine can, as already stated, be explained on the basis of habituation, since novel stimuli were still capable of producing arousal. Thus in contrast to chlorpromazine, it would appear that the sedation produced by reserpine does not seem to be entirely dependent upon the action related to the inflow of impulses into the brain stem from the classical sensory pathways. The site of action of reserpine cannot be defined at this stage, but it is interesting to note that reserpine did not block the conditioned arousal responses, whereas numerous workers have reported that this drug severely depresses conditioned avoidance behaviour[6]. The use of conditioned arousal responses eliminates a task involving muscular co-ordination, and it may well be that responses of this sort may help to distinguish more clearly the selective effects of some drugs from a more diffuse and non-specific action of others.

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Lenticular Effect in Mice of Some Morphine-like Drugs

Drug-induced opacities of the lens of the eye have been recorded by Busche[1] using nitrophenol compounds in chicken. He was unable to produce this in any other small animals except in one particular strain of mice. While investigating the acute toxic effects of a series of reversed esters of pethidine, we observed that a number of these also produced an opacity. This was completely reversible and has been obtained by using other analgesic drugs in several strains of mice.

Fig. 1 shows the typical reaction seen in the eyes of mice after subcutaneous injection of 2 mgm. of (DL)-methadone hydrochloride. All doses mentioned are expressed as mgm./100 gm. of body-weight, and the mice used (both sexes) weighed 18–22 gm. The cloudiness begins to appear at 15 min., reaching a maximum in 50 min., when it slowly disappears. 3 hr. later, the eye is clear again. Smaller doses produce less effect. The opacity develops more slowly with morphine, reaching a maximum in 75–90 min. The effect can be produced in rats but less readily. This species is more sensitive to other toxic actions of these drugs so that the blood concentration to produce an opacity would usually be lethal.

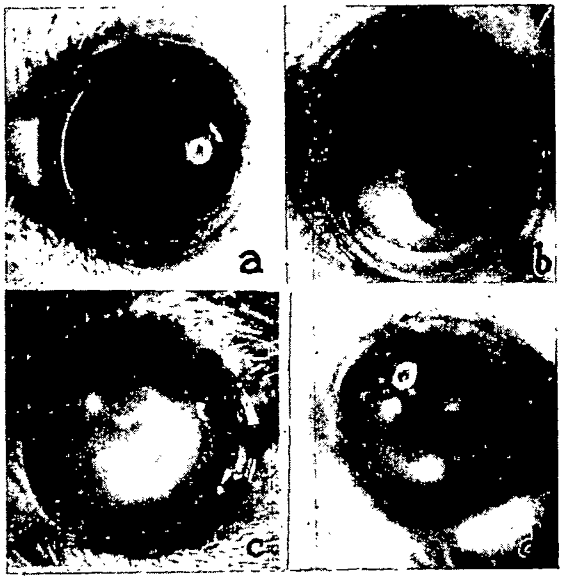

Fig. 1. Various degrees of eye opacity developing in the lens after subcutaneous injection (2 mgm./100 gm.) of (DL)-methadone hydrochloride: (*a*) normal eye; (*b*) 30 min.; (*c*) 50 min.; (*d*) 75 min.

The cloudiness developed in the lens while the cornea remained clear when the eye was viewed through a slit-lamp microscope. Removal of the lens confirmed the site of the opacity. Further investigation has shown that in the intact animal clouding takes place on the anterior surface of the capsule while the lens itself remains transparent. In isolated normal lenses exposed to the same drugs, similar changes occur, but the whole capsule is involved.

A range of drugs has been tested to determine whether the production of this opacity is confined to a certain class of compound. This was found to be the case with narcotic drugs, and particularly with the potent analgesic members of this group. The exceptions were cocaine and papaverine, which had only one-tenth to one-twentieth of the activity of methadone. This effect was produced in at least 20 per cent of the mice by subcutaneous injection, in doses less than 5 mgm., of pethidine hydrochloride and three of its reversed esters (to be published in detail elsewhere); of morphine sulphate and some of its structural analogues, and of (DL)-methadone hydrochloride. Of those tested, the more active the drug was as an analgesic the more readily it produced an opacity.

No effect could be obtained by sublethal doses of the following drugs:

Codeine phosphate
Apomorphine hydrochloride
Mepyramine maleate
Diphenhydramine hydrochloride
Histamine acid phosphate
Atropine sulphate
Physostigmine salicylate
Quinidine sulphate
Amiphenazole hydrochloride
Pentobarbitone sodium
Cyclobarbitone sodium
Phenobarbitone sodium
Acetyl-salicylic acid
N-acetyl-*para*-amino phenol
Phenacetin
Lignocaine hydrochloride
Amethocaine hydrochloride
Procaine hydrochloride

This additional activity of these analgesic drugs has been studied in more detail. In Table 1 a comparison is made of the dose which will produce analgesia in 50 per cent of the mice (*ED*50) as determined by the 'tail clip' method[2], the dose which will kill 50 per cent of the mice (*LD*50) and the dose which will cause cloudiness in 20 per cent of the mice (minimum opacity dose). In each case the dose required to produce the opacity is greater than the corresponding *ED*50, but less than the *LD*50. By changing from the subcutaneous to the intravenous route, clouding of the lens, analgesia and toxicity are increased by all three drugs. When any of these are given intraperitoneally they become less active both as analgesics and in their effect on the eye, yet they are more toxic. Thus it appears that the production of opacity follows the degree of analgesia more closely than the lethal action of these drugs.

The lenticular opacity produced by analgesic drugs can be prevented by the simultaneous injection of

Table 1. Minimum Doses to produce Opacity and Analgesia compared with those for Lethal Effects by Different Routes

Analgesic drugs	Route	*ED*50 (mgm./100 gm.)	Minimum opacity dose (mgm./100 gm.)	*LD*50 (mgm./100 gm.)
Morphine	s.c.	0·5	4·0	50
	i.p.	0·8	6·0	31
	i.v.	0·4	2·5	15
Pethidine	s.c.	1·4	5·0	17
	i.p.	3·1	7·5	12
	i.v.	1·2	2·0	4
Methadone	s.c.	0·3	1·0	4·0
	i.p.	0·4	1·5	2·8
	i.v.	0·3	0·75	1·5

small doses of nalorphine. Furthermore, if the effect has already developed, this antagonist will cause it to disappear in less than one-fifth of the normal time. Nalorphine itself can produce this opacity also but only with doses greater than 50 mgm. As expected, the cloudiness produced by cocaine could not be antagonized in this way.

The modification of this effect by other agents is being investigated. An examination of the actions of these drugs on enucleated lenses is also being carried out because in contrast to the *in vivo* experiments such opacities can be produced by compounds differing widely in pharmacological properties. A detailed report of this work will be published elsewhere.

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Dependence on Age of the Diameter of the Pupil in the Dark

The dependence of the diameter of the pupil of the human eye in the dark on the age of the subject, derived from a large amount of statistical material, is important not only for ophthalmology and neurology but also for physiological and practical optics.

Very little work has been done on this subject, however, and in ophthalmological and optical literature therefore only the values of old measurements after Trendelenburg[1-5] are given (Fig. 1).

In 1950, Birren *et al.*[6] published values for the vertical diameters of the left eyes of 216 subjects in the dark after 90 sec. adaptation, obtained by flash photography with visible light. These differed substantially from Trendelenburg's values (Fig. 1).

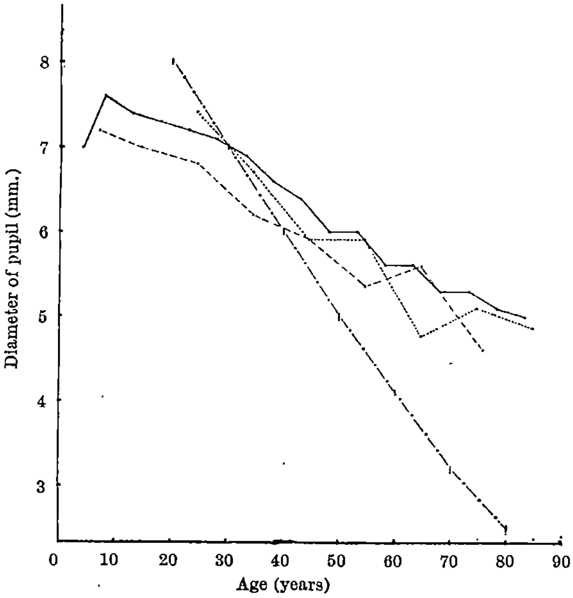

Fig. 1. Mean values of the apparent diameter of pupil in the dark as a function of age according to: Trendelenburg, —·—·—; Birren, ...; Seitz, – – – –; Kadlecová, Peleška and Vaško, ———

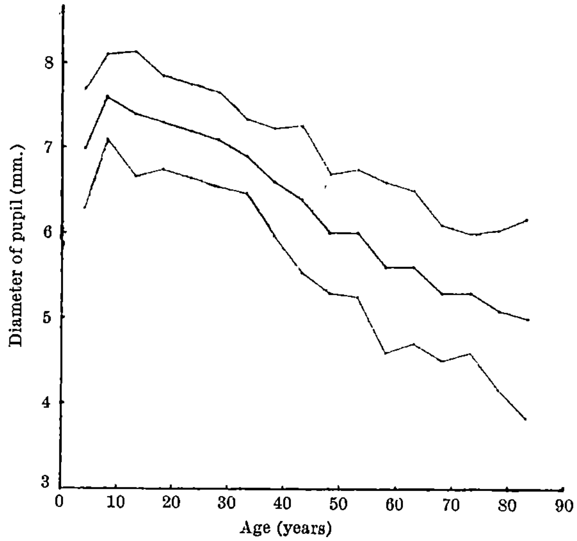

Fig. 2. Mean values of diameter of pupil in the dark with corresponding root-mean-square errors of one measurement as a function of age according to Kadlecová, Peleška and Vaško

Since 1946 we have been measuring the diameter of the pupil in the dark by infra-red radiation—thus eliminating all effects of visible light—with an image converter[7]. The mean values obtained by us for 906 horizontal diameters of both pupils of 453 normal subjects in the dark after 15 min. adaptation are also plotted in Fig. 1. Each subject was clinically examined and cases with diseased iris and nervous system were eliminated.

Later, Seitz published[8] measurements on 208 subjects, made by flash photography in visible light after adaptation for 1 hr. in the dark. These have also been included in Fig. 1, after correcting the mean value of the diameter of the pupil for the age group 40–49 years from 5·1 mm. to 5·9 mm.

In Fig. 2 are plotted the mean values of our measurements giving the corresponding root-mean-square errors δ, calculated from the relation:

$$\delta = \pm \sqrt{\frac{\Sigma\Delta^2}{n-1}}$$

A comparison of these results shows that for young subjects up to about thirty years of age our measurements give lower values than those of Trendelenburg, while from thirty upwards the values are higher and the differences increase with increasing age. The measurements of Birren *et al.* agree approximately with our measurements but are somewhat lower. Seitz's measurements are mostly lower than ours but his curve is practically parallel to our curve.

The accuracy of our method permitting visual observation of the infra-red image of the eye is certainly much greater than methods using flash photography in the dark, since the uncertainty in focusing the image of the pupil after a longer period of adaptation in the dark is removed. Other authors themselves point out the difficulty in maintaining focus[8]. Moreover, as our observations showed, the pupil in the dark is not absolutely at rest and can be seen to perform occasional very fine contractions. Our visual method enables such contractions to be eliminated and the real maximum diameter of the pupil to be measured. Our measurements showed that the diameter does not depend on sex or on the colour of the iris. The diameters of the pupils of both eyes were found to be the same. We found, however (Fig. 2), a visible increase in the mean error (dispersion of values) with age.

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Influence of Hydrocortisone on the Action of Sodium on Isolated Rabbit Auricles

SZENT-GYÖRGYI[1] has demonstrated the importance of the 'intracellular ionic atmosphere' on the contraction of the cardiac muscle, and has suggested that adreno-cortical steroids may influence cellular activity by alterations in membrane permeability. It has also been shown by Selye and Renaud[2] that the action of electrolytes on the heart is influenced by what is termed the 'conditioning' effect of hormones. Further, Holland[3] has presented evidence to show that antiarrhythmic drugs act on the atria by depressing the transmembrane flux of sodium and potassium ions. In this connexion, it would be of interest to examine the effect of the steroid hormones on the action of the ions on the heart. It is well known that when the heart is kept in a medium containing sodium as the only ion it stops beating after some time. Later, when the medium is changed to Ringer solution, the beat recommences, presumably due to sodium extrusion. If a steroid hormone altered the permeability of the cell membrane, it would modify the action of sodium by interfering with sodium traffic across the membrane.

In order to examine this possibility, isolated rabbit atria were kept in oxygenated Ringer solution in a thermostatic organ bath at 37° C. and the contractions recorded on a kymograph. After obtaining normal contractions, the Ringer solution was replaced by physiological saline. There was inhibition of the atrial contraction within a short time. On replacing Ringer solution in the bath the contractions recommenced. Addition of hydrocortisone (kindly made available by Mr. A. V. Mody, Unichem Laboratories, Bombay) to the bath in quantities sufficient to give a final concentration of 25 µgm./ml. resulted in inhibition of the atria. The beats, however, recommenced on changing to fresh Ringer solution, but now replacement of the medium by sodium chloride solution did not result in an early inhibition of the contractions. The inhibitory effect of sodium was significantly postponed by an extremely short pretreatment with the steroid hormone. In fact, in some instances the sodium in the external medium now caused an initial increase in the amplitude of the contraction of the atria. The results are shown in Fig. 1. It is suggested that such an action of the hormone could be due to altered myocardial excitability because of imprisonment of intracellular ions caused by a change in the cell membrane permeability by the steroid.

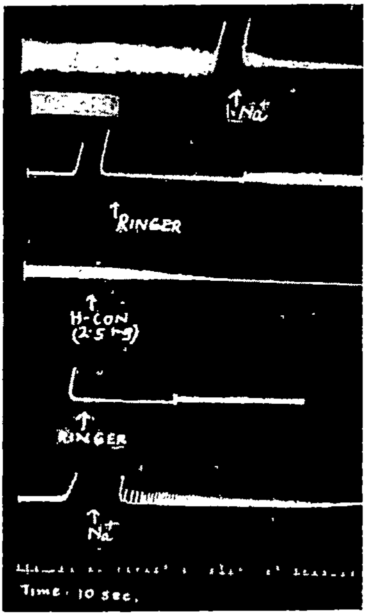

Fig. 1. Effect of hydrocortisone on the action of sodium ions on isolated rabbit auricles

My thanks are due to Mr. N. M. Chavan for all the technical assistance rendered.

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Isolation of Active Mitochondria from Apples

IN recent studies on the physiology of ripening in fruits, attention has been focused on the possible relationship between phosphorylative processes and the climacteric rise in respiration[1-3]. Since many respiratory enzymes are located in the mitochondria, the isolation of these subcellular units in an active state is of great importance in such investigations. Although the apple is the classic object for studies in fruit physiology, attempts to prepare particulate fractions with mitochondrial activity from apples have not been successful. Lieberman[4] isolated particles with cytochrome oxidase activity by grinding apples in a medium containing *tris*-hydroxymethyl aminomethane at *p*H 9·2. By using a homogenizing medium buffered at *p*H 7 with 0·5 *M* phosphate, Neal and Hulme[5] obtained apple particles which oxidized succinate and malate to a slight extent, but only in the presence of the phenolic compound protocatechuic acid. Pearson and Robertson[2] isolated apple particles that had a high endogenous oxygen uptake and that showed some oxidative activity with succinate, citrate and malate. Pearson and Robertson's[2] particles were obtained after a single centrifugation of the homogenate and possibly contained contaminating phenolic compounds. These compounds may have contributed in part to the endogenous oxygen uptake and, in the light of Neal and Hulme's[5] results, may also have been responsible for the oxidation of the added acids. In all these studies, stress has been laid on the necessity for counteracting the high acidity of the tissue when preparing mitochondria from apples.

I have overcome a similar difficulty in the banana[6], and prepared active mitochondria by incorporating sufficient dipotassium phosphate into the homogenizing medium to bring the *p*H of the homogenate to 7. When this method was applied to apples, active mitochondria were also obtained.

The procedure was as follows. Ripe apples were placed in a room maintained at about 1° C. at least 2 hr. before being used, and all subsequent manipulations were carried out at this temperature. 200 gm. of diced pulp were extracted with 300 ml. medium in a Waring blendor connected to a rheostat set at 40 V. for 30 sec. The medium contained 150 mmoles sucrose, 3 mmoles ethylenediamine tetraacetic acid and sufficient dipotassium phosphate to bring the *p*H of the mixture to between 7·3 and 7·4. With the varieties of apples studied, 30–33 mmoles dipotassium phosphate were needed for 200 gm. pulp. The mixture was pressed through a layer of muslin and centrifuged at 1,000*g* for 6 min. The supernatant was centrifuged at 20,000*g* for 15 min. The precipitate was suspended in 40 ml. of 0·5 *M* sucrose – 0·01 *M* phosphate, *p*H 7·4, with the aid of a Potter–Elvehjem homogenizer and recentrifuged at 20,000*g* for 15 min. The precipitate was finally suspended in 0·5 *M* sucrose – 0·01 *M* phosphate, *p*H 7·4, and made up to 4–8 ml. with the same solution. The resultant suspension, which was light yellow, dark yellow or yellowish green, depending on the variety of apple used, was tested for mitochondrial activity in a Warburg respirometer at 30° C.

Each Warburg vessel contained: 40 μmoles phosphate at *p*H 7·4; 15 μmoles magnesium sulphate; 6×10^{-5} μmoles cytochrome *c*; 4×10^{-4} μmoles cocarboxylase; 3 mgm. liver coenzyme concentrate; 2×10^{-3} μmoles adenosine triphosphate; 3 mgm. bovine plasma albumen; 40 μmoles glucose; 650 μmoles sucrose; 40 μmoles substrate and 0·5 ml. of the particulate suspension in a final volume of 2 ml. The sources of the biochemicals and the analytical procedures used are described elsewhere[6].

In the absence of added substrate, the apple particles had an oxygen uptake of 0–1 μl. per vessel. The oxidative activity of the particles towards various substrates is shown in Table 1. The succinoxidase activity of the particles isolated from each variety was high. Malate and α-oxoglutarate were oxidized by the particles at a much lower rate than succinate. The ability of the particles from Ohenimuri and York Imperial apples to oxidize citrate is doubtful; the particles from the other varieties oxidized citrate at a rate comparable to that with α-oxoglutarate or malate as substrate. No browning of the reaction mixture was ever observed, an indication that the oxidation of phenolic compounds was not taking place.

Table 1. Oxidative Activity of Mitochondria isolated from Various Apple Varieties. Conditions indicated in Text

Variety	Mitochondrial nitrogen per vessel (mgm.)	$QO_{2(N)}$ with			
		Citrate	α-Oxoglutarate	Succinate	Malate
Golden Delicious	0·51	53	59	106	43
Granny Smith	0·62	44	66	139	62
Ohenimuri	0·20	10	60	220	60
Starking	0·21	86	76	276	133
White Winter Pearmain	0·38	39	63	158	39
York Imperial	0·23	13	39	169	56

The oxidation of pyruvate by these particles could not be demonstrated unequivocally; the oxygen uptake in the presence of pyruvate and catalytic amounts of succinate was only slightly higher than the oxygen uptake with succinate alone.

These apple particles differ from the preparations described in the literature[2,4,5] in having virtually no endogenous oxygen uptake, in their ability to oxidize four members of the tricarboxylic acid cycle, and in the independence of this oxidative activity from polyphenolase activity. It is hoped that further refinement of the procedures described above will lead to the isolation of apple cytoplasmic particles with a full spectrum of mitochondrial activity, as evidenced by their ability to oxidize pyruvate via the tricarboxylic acid cycle and to carry out the concomitant phosphorylations.

This study was supported by a grant from the South African Council for Scientific and Industrial Research. The nitrogen analyses were kindly performed by Mrs. M. C. van Beijma.

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Artificial Light and Sexual Maturity in the Fowl

In a recent communication[1] we outlined a general hypothesis to account for the relationship between day-length and sexual maturity in the fowl, *Gallus domesticus*. We have since conducted an experiment which offers striking evidence in support of the hypothesis that sexual maturity is affected by changes in day-length and not by the absolute day-length.

Four groups, each of 150 Rhode Island Red × Light Sussex pullets hatched on December 4, 1957, were reared under identical conditions except for light treatments as follows. Two groups served as controls and received natural daylight only (latitude, 51° 27′ N.): the other two groups were given supplementary lighting to provide continuous illumination during the first week of life and thereafter day-length was reduced by 35 min. each week to reach a level of 14 hr. 5 min. at 17 weeks of age. On April 3 (17 weeks) all four groups were transferred to laying cages where they have been treated uniformly in every respect. Artificial light was not used in the laying house until after the summer solstice, by which time all the birds were in lay.

Table 1. AVERAGE RESULTS TO 37 WEEKS OF AGE

	No. of pullets housed	Age at first egg (days)	Body-weight at:		Eggs per pullet housed: By grades (oz.)			Total
			20 wk. (gm.)	30 wk. (gm.)	$< 1\frac{7}{8}$	$1\frac{7}{8}$–$2\frac{3}{16}$	$>2\frac{3}{16}$	
Controls	285	145·6	2,371	2,772	35·5	24·8	4·3	64·6
Lighted	291	169·7	2,222	2,867	18·3	37·4	7·9	64·1
Difference		24·1*	149†	95†	16·7†	12·6†	3·6†	0·5

* Significant, $P < 0·01$. † Significant, $P < 0·05$.

Average age at first egg is given in Table 1. It is clear that the artificial pattern of decreasing day-length delayed sexual maturity even though it involved the provision of more light than was available to the naturally lit controls. The possibility that long day-lengths, *per se*, inhibit sexual maturity has been eliminated by the work of Hutchinson[2] and others.

In this experiment the net increase in day-length experienced by the controls between hatching and sexual maturity was 6·67 hr. and the net increase experienced by the lighted groups was 8·02 hr. The expected difference in sexual maturity between them, on the basis of the regression coefficient calculated from previous results[1], would therefore be $1·64 \times (6·67 + 8·02) = 24·1$ days. That this agrees so exactly with the observed difference may be coincidental. However, the results of this experiment do agree quantitatively as well as qualitatively with the hypothesis already published. It remains to be seen whether our regression coefficient can be treated as a constant for all stocks.

To measure the benefits which accrue from using lights to delay maturity in pullets hatched in December, records of egg-production, egg-weight, body-weight and mortality will be kept to 450 days of age. Table 1 gives the results up to 37 weeks, and it is apparent that the light treatment has produced an improvement in rate of lay sufficient to offset the 3 weeks delay in maturity. Early egg-size has also been substantially increased, presumably because of the greater body-size eventually attained by the lighted groups.

Full details of this experiment, which is being conducted with the aid of funds provided by the Agricultural Research Council, will be reported elsewhere in due course.

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Male Sterility in *Brassica*

MALE sterility has been reported in thirty-one genera[1], but not previously in the genus *Brassica*. In the course of breeding work at this Station male sterile plants have been found in inbred material of three varieties of brussels sprout[2-4]. In one of these varieties one male sterile plant was also found in 5,000 non-inbred plants inspected[4].

Meiotic division in the male sterile plants proceeded normally, but in the majority of anthers pollen development ceased at the tetrad stage, after which the young pollen grains degenerated. At flowering time the anthers were shrivelled (2–4 mm. long). In about 1 per cent of anthers occurring at random on male sterile plants, about 10 per cent of the pollen tetrads continued development to produce apparently normal pollen grains. Such anthers developed to their normal length (10–15 mm. including filament) although they were emaciated and indehiscent. After teasing out such anthers and applying the contents to normal styles, no seed was obtained. The flowers of male sterile plants were usually, though not invariably, smaller and paler in colour than those of normal plants.

This male sterility was found to be inherited as a simple recessive at a single locus. The expression of dominance of male fertility was imperfect, about 25 per cent of heterozygotes producing up to six male sterile flowers (about 1 per cent of the flowers on the plant), usually at the base of the inflorescence. There was some indication that the expression of dominance was affected by temperature, since heterozygotes kept at 70° F. produced more male sterile flowers than others kept at about 55° F.

Male sterility is expected to be of use for the production of hybrid seed in the inbreeding and hybridization programme with brussels sprouts at present in progress at this Station.

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Nitrogen Fixation by Non-nodulated Plants, and by Nodulated *Coriaria arborea*

IN a recent communication, Bond[1] discusses the probability that nodulated plants of *Coriaria* fix atmospheric nitrogen in the same way as other non-leguminous nodulated plants with which he has worked. This supposition is confirmed by the results of a trial which was made during the course of other work using nitrogen-15. Wild seedlings of *C. arborea* about 6 in. high, each with a cluster of pink nodules 1–2 mm. long near the crown, were collected from a rocky roadside cutting near Nelson, and grown in quartz sand watered with a minus-nitrogen culture solution. Results from exposing these plants to an isotopically enriched atmosphere are given in Table 1. There was considerable fixation of nitrogen, which may have occurred in the leafy shoots as well as in the roots.

During the past four years I have been investigating the possibility of nitrogen fixation by non-nodulated plants which make vigorous growth in poor soils. Evidence, which is more fully presented and discussed

Table 1

Duration of exp. (days)	Atom per cent excess nitrogen-15 in atmosphere	Plant		Atom per cent excess nitrogen-15 plant material
12	15	*Coprosma robusta*	tops	0·19
			roots	0·012
7	31	*C. robusta*, shoots only		0·024
		C. robusta, shoots only		0·047
		Prunus armeniaca, shoots only		0·058
14	7	*Pinus radiata*	tops	0·056
			roots	0·029
9	About 15	*P. radiata*, root exposed only	tops	0·004
			roots	0·042
14	5	*Dactylis glomerata*	tops	0·05
			roots	0·52
18	16	*D. glomerata*	tops	0·016
			roots	0·225
10	About 10	*D. glomerata*, roots exposed only	tops	0·003
			roots	0·014
14	25	*Epilobium erectum*	tops	0·51
			roots	0·014
28	6	*E. erectum*	tops	0·07
			roots	0·07
18	6	*E. erectum*	tops	0·020
			roots	0·095
28	About 3	*Coriaria arborea*	tops	1·177
			roots	0·695

in another publication, has been gathered from three lines of inquiry :

(1) Records of field-experiments published by a number of different workers for the yield of various crops, in relation to fertilizer used and soil nitrogen, over periods of many years, have shown substantial gains of the order of 30–50 lb. nitrogen/acre/year in the absence of legumes or other nodulated plants. Records of native vegetation give similar figures for large, unexplained gains in soil nitrogen. For *Pinus radiata* plantations growing on sand dunes or depleted soils in New Zealand, I made measurements and analyses which showed a gain over twenty-five years of 38 lb. nitrogen/acre/year.

(2) Pot experiments with a number of non-nodulated plants grown in a strictly no-nitrogen medium, in the absence of non-symbiotic nitrogen-fixing micro-organisms, have shown substantial gains in nitrogen over periods of 6 months to 3 years.

(3) Experiments have been carried out with nitrogen-15 in which either whole plants grown in a minus-nitrogen culture in enclosed glass pots, or shoots and roots separately, were exposed to an atmosphere enriched in the heavy isotope. Significant gains in nitrogen-15 have been made by the growing plants, and some typical results are given in Table 1. Leafy shoots (tops) and roots were assayed separately ; figures for control material were 0·003–0·005 atomic per cent excess nitrogen-15 (all figures with respect to cylinder nitrogen).

The evidence from these three lines of investigation leads to the conclusion that a number of non-nodulated plants are able to utilize atmospheric nitrogen. In the case of *P. radiata* and cocksfoot grass, it appears likely that fixation is a function of the mycorrhizas, though it still has to be proved that bacteria in or on these fungal roots are not also implicated. In the case of fixation in the leafy shoots it is possible that bacterial glands are responsible for the effect, but it is also possible that some leaves may yet be found to have a capacity for using nitrogen gas in the absence of micro-organisms.

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Effects of Water-Strain on the Minimum Intercellular Space Carbon Dioxide Concentration Γ in Wheat Leaves

In a recent communication, Rees[1] reported that midday closure in the oil palm was associated with water-strain and correlated in extent with total evaporation. There was also a relation with air temperature showing striking stomatal closure between 30° and 35° C., strongly reminiscent of the results of Heath and Orchard[2] for the log Γ/leaf temperature relation in onion and coffee leaves and of those of Heath and Meidner[3] for the stomatal aperture/leaf temperature relation in onion leaves closed at the tip. Rees concludes : "Although increasing leaf temperature may cause stomatal closure, it is clear that midday closure of stomata may also be influenced by water-strain . . .". In work carried out with wheat leaves we found a relation between degree of water-strain and Γ (the minimum intercellular space carbon dioxide content[2]) which is very relevant to this conclusion.

It was found that when detached wheat leaves were subjected to different degrees of water-strain by placing their sheaths in mannitol solutions of different concentrations, Γ values changed very significantly even with leaf temperature and light intensity maintained constant (Table 1).

Table 1. Mean Γ Values (maintained for 20 min.), in Parts per Million of Carbon Dioxide, from Eight Wheat Leaves (Leaf temperature, 25° C. ; light intensity, 900 foot-candles ; relative humidity, 50 per cent)

Successive treatments	0·2 M mannitol	0·4 M mannitol
Water	78	77
Mannitol	94	116
Water	83	82

Significant difference for P 0·05 = 5·9 ; significant difference for P 0·001 = 10·6

Similar increases in Γ were obtained by withdrawing the water supply to produce water-strain, instead of using mannitol, and on restoring the water supply Γ gradually returned to its original level ; the increases recorded in Table 1 are not therefore simply attributable to the mannitol being metabolized by the leaf.

Porometer measurements showed that stomatal closing movements accompanied the increased Γ values produced by water-strain, and some re-opening occurred when Γ fell once more.

These results suggest the existence in the wheat leaf of a carbon dioxide-operated stomatal closing response to water-strain, similar to the carbon dioxide-operated response to high temperature in onion, and probably in coffee leaves, previously discussed[2,3]. In different species midday closure may be mediated by one or the other or both of these mechanisms. Wheat stomata have not in fact been recorded as showing midday closure, and information is not yet to hand as to whether wheat leaves show the sudden increase in Γ with temperature rise above 30° C. found with onion and coffee; stomatal closure does, however, occur in response to dry air[4].

Special significance may be attached to a regularly observed initial decrease in Γ (of about 10 per cent) on placing the leaf sheaths in mannitol solution, which preceded the increase. This decrease was accompanied by the frequently recorded 'passive' initial stomatal opening on wilting. It is possible that epidermal shrinkage, perhaps due to the large 'motor cells', altered the amount of light reaching the chlorenchyma, for it was observed that in this condition the leaves appeared darker suggesting that more light was absorbed. Whatever the mechanism, however, such a temporary decrease in Γ would tend to accentuate stomatal opening—thus the temporary opening on wilting may, in wheat, be in part an effect due to carbon dioxide.

This work was carried out in the Research Institute of Plant Physiology of the Imperial College of Science and Technology, London, with the support of a grant from the Nuffield Foundation. Full experimental details will be published elsewhere in due course, and this line of investigation is being pursued further.

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Mode of Intercellular Transfer of Herpes Virus

In previous studies[1] on the growth of the *HFEM* strain of herpes virus in HeLa cells, attempts were made to estimate the proportion of infected cells by inoculating the intact cells on to the chorioallantois of fertile hens' eggs and determining the number which formed pocks. It is known that the chorioallantois is at least ten times more sensitive than HeLa cells to this strain of virus released from HeLa cells. Nevertheless, the proportion of infected (pock-forming) cells was much lower than would be expected from the deduced input of HeLa infective virus, and it was concluded that the cells might not survive long enough to make virus in this environment.

Later, Wildy *et al.*[2] cultured single cells in microdrops of medium and determined the number which released pock-forming virus; the proportion was higher but still less than would be expected, and not related to input of virus per cell over the range tested.

The development by Farnham[3] of a plaque technique in monolayers of HeLa cells under fluid medium has since allowed more accurate determination of the numbers of infecting particles in relation to number of cells. It has also permitted the direct estimation of the number of infected cells by their ability to form plaques (that is, infective centres).

The media and other solutions used and the techniques for preparing cells and virus were as described elsewhere[1,3]. In several experiments monolayers of 3–5 × 10^5 HeLa cells were exposed to 5 × 10^5 HeLa plaque-forming units of virus for 2 hr. The residual virus was removed by treating the cells with antiserum, which was itself removed by washing. This resulted in an input of 2·2 × 10^5 plaque-forming units per monolayer or 0·44–0·78 per cell. The cells, containing virus in the lag phase of growth, were then suspended in sodium ethylenediamine tetraacetate, counted, diluted in maintenance medium, and lots of 50 cells were inoculated on to uninfected monolayers of HeLa cells. Plaques were counted microscopically after 3 days.

In the pooled results of five similar experiments with 27 readings the mean number of plaque-forming cells was 21·8 (standard error ± 1·85) or 43·6 per cent. Variation in the number of cells inoculated gave proportional variation in the number of plaques. When the cells were disrupted by freezing before plating less than 2 per cent formed plaques. The mean input for the five experiments was 0·59 plaque-forming units per cell which, according to Poisson distribution, should result in infection of 45 per cent of cells, so that the method apparently detected most of the infected cells. However, only 7·7 per cent of these cells formed pocks on the chorioallantois.

Concurrent experiments on inhibition of clone formation by single cells taken from monolayers infected with the same virus seed, have shown that the proportion of cells which are prevented from dividing also corresponds to the input of HeLa plaque-forming units[4].

Since mitosis of the infected cells is inhibited, it follows that plaque formation is due to spread of infection to contiguous cells and this might obviously be due to release of virus. When single cells from infected monolayers were isolated in drop cultures, however, the number releasing infective virus was much less than the number of cells which gave rise to plaques. Thus in experiments with the same seed and dose as in the series quoted, where 43·6 per cent of cells formed plaques, none out of 30 cells released virus infective for HeLa cells, and only 3 in 80 (4 per cent) released virus detectable on the more sensitive chorioallantois.

If very few infected cells release virus capable of infecting HeLa cells or even chick cells, how then does the virus spread to the contiguous cells in a monolayer to cause the typical cytopathic effect? It is known that addition of antiserum after virus adsorption does not prevent the development of a plaque, which suggests that it does not depend on spread of released virus passing from cell to cell through medium. In addition, it has now been found that infected cells initiated plaques when they were added to monolayers in medium already containing strong antiserum. In two experiments 24 per cent and 10 per cent of cells formed infective centres in patients' antiserum (pock neutralization index 10^4) against 50 per cent and 36 per cent respectively in normal serum.

Multinucleate syncitia are a constant finding in HeLa cells infected with the *HFEM* strain of herpes virus, and it has been shown that these are due to cell fusion rather than nuclear division (ref. 5 and Stoker, M. G. P., and Newton, A., unpublished). The herpes plaque in its early stages consists, in fact, of a single syncitial mass with many nucleic and no intervening cell walls. These fused cells may be observed as early as 9 hr. after infection, and it is therefore possible that the virus spreads by fusion of an infected cell with its uninfected neighbours.

If virus does spread from cell to cell in this way by fusion of the cytoplasm it might be transferred as infective, but unreleased, virus particles, or alternatively, in a vegetative, non-infective state. If it is due to infective virus, the latter ought to be detectable as such by disintegration of the cells at the end of the growth period.

Single cells from a monolayer infected as above were isolated in micro-drops and were burst by a single cycle of freezing and thawing after incubation for 30 hr., which was previously shown to be the optimal time for detecting released virus in single-cell cultures[2]. Only one cell in 130 (0·8 per cent) released HeLa-infective virus under these conditions, despite the fact that 43·6 per cent of the intact cells could give rise to plaques. In other experiments with a higher input (1·0 plaque-forming units per cell) and using the more sensitive pock assay, only 4 cells in 80 (5 per cent) released virus after freezing.

More thorough methods of cell disintegration and other sampling times will be needed to confirm the absence of infective virus in the majority of plaque-forming cells, but these results do raise the possibility that vegetative herpes virus can spread from cell to cell.

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Responses of Insects to Polarized Light in the Presence of Dark Reflecting Surfaces

The ways in which arthropods, such as bees[1–3], ants[4,5], Diptera[6], insect larvæ[7], Cladocera[8,9], Amphipoda[10] and Decapoda[11], orientate in respect to the plane of vibration of polarized light are controversial. Some authors have investigated by optical and electrophysiological means various arthropod eyes and their elements for the properties of an analyser[12,13], either those of a Nicol prism or those of some internal reflexion device; whereas others have been more concerned with external visual conditions[3] in which orientation to polarized light is observed, and have tried to explain it on the basis of mere brightness discrimination. The present communication has followed the latter approach and was based on the following considerations.

The three responses thus far used in demonstrating effects of light polarization, namely, the linearity of tracks, their angular orientation to the plane of polarization and responses to single sudden changes of this plane, are not phenomena which are very striking. It was thought that clearer results might be obtained in situations where continuous rotation of the plane of vibration would, by vectorial summation[14], induce strong rotatory optomotor reactions. Such a situation is provided in the apparatus shown in Fig. 1. This apparatus consists mainly of two coaxial circular turntables which can be moved independently of each other. On the upper one (drawn in black), which is mostly kept stationary, is placed an insect enclosed between two watch-glasses about 5 cm. in diameter. This turntable also carries a black cylinder and diaphragm shielding the insects from stray light. The lower and larger turntable carries a black cylinder covered either by a 'Polaroid' sheet or by a transparent sheet of plastic crossed in the middle by a black strip 3 cm. wide. This lower turntable can be turned by hand in either direction. The apparatus is placed in a dark room, 100 cm. beneath the open end of a piece of stove-pipe, 60 cm. long, which contains near its upper end a light bulb of about 100 W. Only about half the watchglass is visible to the observer when the apparatus is in position, and thus the direction of movement of an insect in it can be noted as it comes into view.

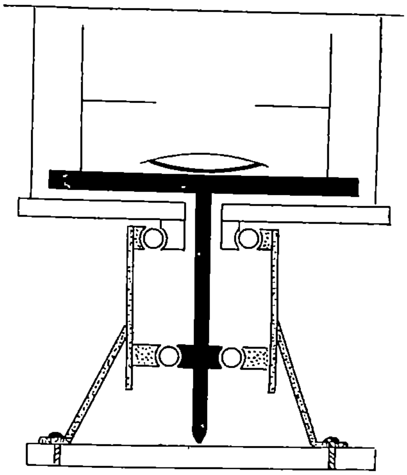

Fig. 1

Many species of flies, ants and moths were found to react to the rotation of light polarization. Table 1 summarizes the results of six typical experiments, each involving forty observations. It shows that (1) rotation of the plane of vibration induced clear optomotor reactions, but that (2) these occurred only in special visual circumstances, for example, when

Table 1. Reactions of Three Male *Aedes aegypti* (*a*, *b*, *c*), Two Female *Drosophila melanogaster* (*d*, *e*) and One Male *Thaumatomyia glabrosa*. (*f*) to Forty Changes in the Direction of Rotation of a 'Polaroid' or a Strip

Bottom of watchglass	External cylinder carrying	Rotation of 'Polaroid' or strip changed to	Insect circling clockwise *a*	*b*	*c*	*d*	*e*	*f*	following rotation* *a*	*b*	*c*	*d*	*e*	*f*
Covered with black passe-partout	'Polaroid' screen	clockwise 20 ×	16	14†	17	15	17	18						
		anticlockwise 20 ×	8	7†	3	3	2	3						
		total changes 40 ×	24	21	20	18	19	21	28	27	34	32	35	35
Transparent, standing on white paper	"Polaroid' screen	clockwise 20 ×	12	9	14†	8	13	13						
		anticlockwise 20 ×	11	10	13†	7	11	9						
		total changes 40 ×	23	19	27	15	24	22	21	19	21	21	21	24
Transparent, standing on white paper	Black strip, 3 cm. wide	clockwise 20 ×	12	12	17†	18	16	15						
		anticlockwise 20 ×	5	6	2†	1	5	6						
		total changes 40 ×	17	18	19	19	21	21	27	26	35	37	31	29

* Any number greater than 27 is significant at the 0·05 level. † Insect moving upside down.

the hollow of the lower watchglass was coated with black passe-partout (gum strip), whereas on a light background either no reaction or only a weak one occurred. Table 1 also shows that (3) optomotor responses similar to those induced by the 'Polaroid' were observed after a clear sheet carrying a black strip was substituted for it. The polarized light reflected from a white background towards the centre of the watchglass, where the insect's eyes were, is largely depolarized, and no great differences of intensity occur in different directions. On the other hand, a great deal of light is reflected from the black passe-partout in the plane of vibration, but very little vertically to it. Rotation of a 'Polaroid' thus results in the rotation of a light band in the dark part of the visual field of the insect. This effect can easily be demonstrated to the unaided human eye by means of a somewhat larger model. Findings (2) and (3) confirm the conclusions, derived from quite different experiments, of Baylor and Smith[8] on bees, namely, that some motor responses in insects are not induced by the polarized light directly perceived, but by light reflected from a dark background.

The above experiments do not, of course, preclude the possibility that the eyes of some arthropods, and perhaps of other animals, may have true analyser properties. Faint visual effects, comparable in intensity to the perception of Haidinger's figure by man[15], possibly occur widely; and stronger effects may occur in eyes possessing bulging lenses, like those of the Cladocera or of the tadpoles of *Xenopus*, where simple internal reflexion may operate[3]. Bees flying under large areas of polarized light from the sky[1] and insect larvæ crawling in the open[7] seem to react overtly to these large-scale patterns. On the other hand, in certain circumstances, when polarized light from a small source is reflected from dark reflecting surfaces, as in von Frisch's bees dancing on a horizontal comb[1,2], or in Santschi's ants crawling on sand inside a dark tube[4], maintenance of the perceived reflected light pattern provides a sufficient explanation. Attempts to explain reactions to light polarization by means of special, optical and nervous arrangements in the eye concerned and to demonstrate their existence by electrophysiological means, should in future be confined to visual situations, where the above explanation does not apply.

I wish to thank Prof. B. Hocking and Mr. W. Klaassen of the University of Alberta for help in these experiments, and Dr. E. R. Baylor of Woods Hole for sending me his mimeographed lecture notes.

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An Artificial Diet for the Laboratory Rearing of Locusts

Locusts are being increasingly used for research and teaching purposes, but one of the main difficulties involved in maintaining a culture is the provision of an adequate supply of fresh green grass throughout the year[1]. A further disadvantage of this grass diet was revealed by biochemical investigations into the variation with age of the concentration of reducing substances in the hæmolymph of *Schistocerca gregaria* Forsk., to be reported elsewhere. The above pattern of variation was partially masked by the considerable divergence of many results from the mean values. In view of these divergences, which were thought to be due to differences in the quality of the grass diet, an artificial diet was formulated. The use of this diet, to which very small quantities of fresh green grass were added, considerably reduced these divergencies.

Three series of experiments were later carried out in order to determine the effect of rearing both the desert locust *Schistocerca gregaria* Forsk. and the African migratory locust *Locusta migratoria migratorioides* (R. and F.) on (*a*) artificial diet alone, (*b*) artificial diet plus fresh green grass added once a week for 24 hr., and (*c*) artificial diet plus a very small quantity of fresh green grass given daily. In each series an equal number of control cages were set up in which the locusts were fed on fresh green grass given daily.

In all experiments the two species *L. migratoria* and *S. gregaria* were reared in initial batches of 20 in 12-litre cages of plastic and metal, kept in a constant-temperature room at 28° C., the temperature in the cages being 34–36° C. during the day and falling to 28° C. at night. This day temperature was maintained by placing five cages around each 100-watt bulb, which was on from 9 a.m. to 4 p.m. The relative humidities in both the control and artificial diet cages were 55–60 per cent in the mornings and 45–50 per cent in the late afternoons. Twigs, which were scarcely eaten during the course of the experiments, were placed in each cage to facilitate moulting by acting as perches. Each cage also

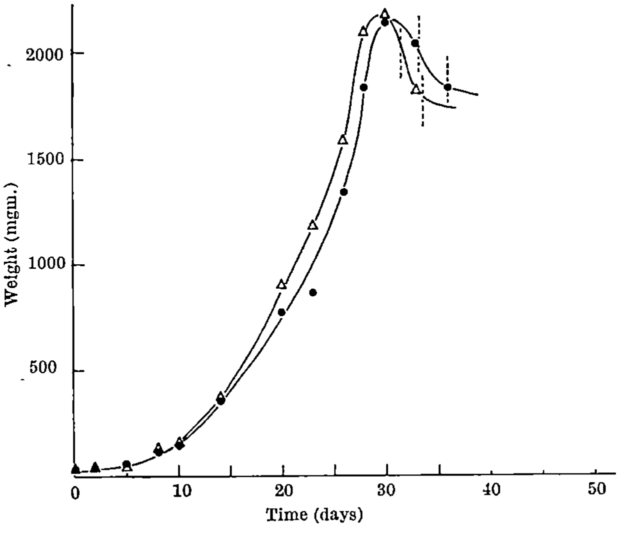

Fig. 1. Growth curves for *S. gregaria* females, series 1. —△—, Control (grass) diet; —●—, artificial diet. Final moult is indicated by broken vertical lines

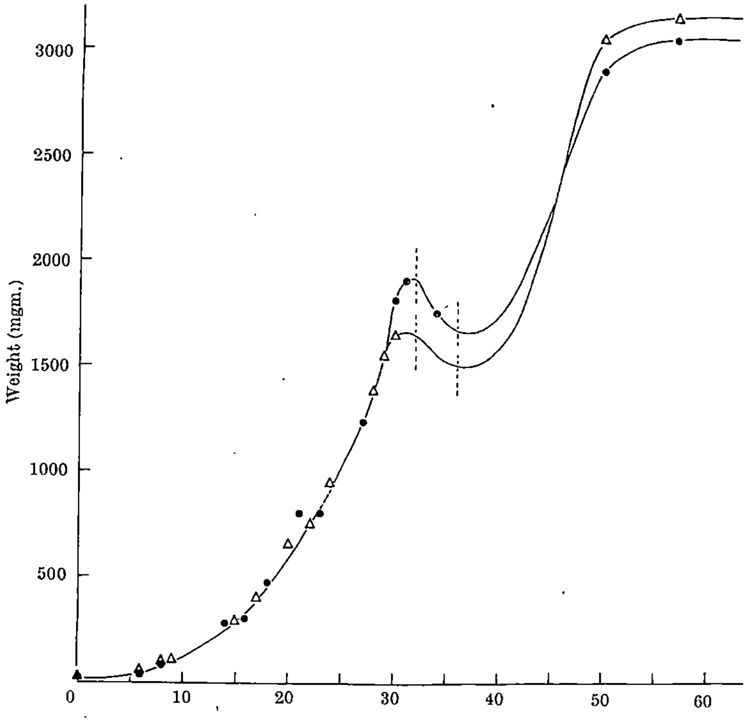

Fig. 2. Growth curves for *S. gregaria* females, series 3. —△—, Control (grass) diet; —●—, artificial diet. Final moult is indicated by broken vertical lines

had a dish containing cotton-wool soaked with water.

The artificial diet was offered as a dry mixture of the following composition: bran, 2; dried whole milk, 2; grassmeal, 2; dried brewers' yeast, 1 (parts by volume). The results of the first series of experiments in which artificial diet was fed to the experimental group of locusts are shown in Fig. 1.

Although the growth curves and weights at the final moult were similar for both the experimental and control groups of *S. gregaria*, the coloration of these groups differed. The normal pink coloration of the sexually immature adults was lacking in the experimental group of locusts, as was the yellow normally characteristic of sexual maturity. Further, a previous experiment had shown that although eggs were laid by these locusts, they were not viable. The mortalities were also significantly different, being 30 per cent in the control group and 80 per cent in the experimental group of *S. gregaria*. In each species the males and females showed similar mortalities.

The results of the second series of experiments in which a large quantity of fresh grass was provided once a week for 24 hr. were not so good for either species as those of series 1. There were considerable differences in the growth curves, the weights at the final moult, the times of development and the mortalities. However, the coloration of both sexually immature and mature adult experimental *S. gregaria* was the same as that of the controls.

The third series of experiments provided the best results. In these, artificial diet mixed with chopped-up grass was fed daily to the experimental locusts. The amount of grass supplied to each cage, in blades about ⅛ in. wide, was equal to the sum of the lengths of locusts in that cage. Fig. 2 shows the growth curves for experimental and control females of *S. gregaria*.

In each species results for males and females were similar. With *S. gregaria* there was a tendency for the final moult of the experimental locusts to occur a few hours before and at a slightly greater weight than that of the controls. The mortalities were very nearly the same, averaging 28 per cent for the experimental locusts and 23 per cent for the controls. No difference in coloration could be detected up to the end of the sexually immature adult stage, although the normal yellow colour of the sexually mature males was acquired by the experimental locusts one week later than by the control group. Once the locusts were mature, the rate of laying of egg pods was the same, as was the period of incubation and the weight and colour of the emerging hoppers.

With *L. migratoria* the results for the three series of experiments were not so good, since the times of development were increased, the weights of all stages were reduced and the mortalities of experimental *L. migratoria* were considerably greater than those of the control group. These results are compatible with the fact that, in the field, the African migratory locust feeds mainly on grass whereas the desert locust does not.

It is therefore suggested that this artificial diet plus a small daily addition of fresh grass may be of use in maintaining cultures of *S. gregaria* in places where large quantities of fresh grass are not available throughout the year, the amount of grass required daily being of the order of 2–3 gm. for 50 adult locusts and correspondingly less for the preceding instars. The artificial diet alone may be useful in physiological and biochemical investigations on one instar where variations in diet tend to mask the changes due to development. In more extended studies the use of small quantities of a single species of grass grown throughout the year, in addition to the artificial diet, may also eliminate seasonal variations in diet. Full details of this work will appear elsewhere.

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Albinism in the Migratory Grasshopper, *Melanoplus bilituratus* (Wlk.)

HUNTER-JONES[1] discovered albinism in the desert locust, *Schistocerca gregaria* (Forsk.), and established an albino strain of this species. A single, nearly colourless, male of the migratory grasshopper, *Melanoplus bilituratus* (Wlk.)—formerly known as *M. mexicanus mexicanus* (Sauss.)—appeared in a culture at the Saskatoon laboratory in 1954. Although the characteristic as observed in this individual and his descendants may not conform to the strict definition of albinism, the term is retained here for its convenience.

The nearly colourless male was mated with a number of normal females of the same species, and the resulting F_1 progeny were all normally pigmented; the F_2 progeny contained a minority of grasshoppers resembling the albino parent, but the observed ratio of normal and albino individuals could not be reliably interpreted on a genetic basis. Later, male albinos were back-crossed to phenotypically normal F_1 hybrid females, and a progeny of about 500 was produced. This progeny was divided in the ratio of 238 albino : 257 normal ($\chi^2 = 0{\cdot}365$; $P = 0{\cdot}6$, basis 1 : 1 hypothesis). When both parents were albinos, only albino progeny were produced. The genetic basis of the albinism is therefore probably a single recessive gene.

In a mixed population of nymphs, albino individuals are not distinguishable by any means yet discerned until after the first nymphal moult; they are then unmistakable, though a slight expression of melanism persists. For example, the chevron pattern on the femora remains faintly discernible. In adults, a certain amount of rather diffuse melanic pigment appears and tends to intensify with age, although albino individuals remain easily distinguishable from normal ones throughout the adult life.

Albinos of *M. bilituratus* reared in the laboratory appear to grow as rapidly and to show the same degree of robustness and activity as normal individuals. In pure culture they appear to mate normally but a vigorously multiplying stock has not yet been produced; presumably egg production, or the viability of the eggs, is subnormal. Most of the albino individuals obtained have therefore been produced by matings involving at least one heterozygous parent. By successive breeding back to normal stock, it is hoped to overcome the apparent difficulties now encountered in maintaining a pure culture of albinos.

The survival value of the albino characteristic under natural conditions in western Canadian altitudes would be expected to be low, if only because individuals having the characteristic would presumably be unable to benefit from insolation to the same extent as the rather heavily melanized grasshoppers in the normal population.

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A New Type of Insecticide

RECENTLY, I found[1] that strains of *D. melanogaster* characterized by resistance to DDT, BHC, parathion and other insecticides were susceptible to phenylthiourea, while the majority of strains susceptible to DDT were resistant to phenylthiourea.

In previous papers[2,3] the genetical relation between resistance to phenylthiourea and to other insecticides has been discussed and the hypothesis was introduced that the dominant gene on the second chromosome, which confers resistance to DDT, BHC and parathion, also confers abnormal susceptibility to phenylthiourea. The dominant gene on the third chromosome which confers resistance to nicotine sulphate also confers resistance to phenylthiourea.

Accordingly, it may be presumed that susceptibility to phenylthiourea results from the pleiotropic expression of the dominant gene for resistance to DDT, BHC and parathion on the second chromosome. This assumption suggests that the mixture of DDT, BHC or parathion with a substance correlated negatively to these compounds, such as phenylthiourea, might have an effective insecticidal action and might not produce flies resistant to these mixtures even after continuous use.

In order to test this assumption, the following backcross was carried out by using a strain resistant to DDT and nicotine sulphate (Hikone-*R*31 wild

Table 1. THE NUMBER OF F_2-FLIES OF EACH PHENOTYPE IN THE BACKCROSS. (500 F_2 LARVÆ WERE USED FOR EACH TEST BY THE LARVAL TEST METHOD)

Phenotypes	*bw* ; *st ss*	*bw*	*st ss*	+
Genotypes	$\frac{bw}{bw}$; $\frac{st\ ss}{st\ ss}$	$\frac{bw}{bw}$; $\frac{st\ ss}{R\text{—}NS}$	$\frac{bw}{R\text{—DDT}}$; $\frac{st\ ss}{st\ ss}$	$\frac{bw}{R\text{—DDT}}$; $\frac{st\ ss}{R\text{—}NS}$
DDT, BHC, Parathion	*S*	*S*	*R*	*R*
Nicotine sulphate	*S*	*R*	*S*	*R*
Control	121	111	121	137
DDT 0·5 m*M*	18	9	110	116
DDT 1·0 m*M*	2	2	88	115
DDT 1·5 m*M*	0	0	90	98
DDT 2·0 m*M*	0	0	97	96
DDT 10·0 m*M*	0	0	99	101
PTU 3·0 m*M*	0	114	0	0
PTU 5·0 m*M*	0	109	0	0
PTU 3·0 m*M* DDT 0·5 m*M*	0	101	0	0
PTU 3·0 m*M* DDT 1·0 m*M*	0	71	0	0
PTU 3·0 m*M* DDT 1·5 m*M*	0	0	0	0
PTU 3·0 m*M* DDT 2·0 m*M*	0	0	0	0
PTU 5·0 m*M* DDT 0·5 m*M*	0	113	0	0
PTU 5·0 m*M* DDT 1·0 m*M*	0	75	0	0
PTU 5·0 m*M* DDT 1·5 m*M*	0	0	0	0
PTU 5·0 m*M* DDT 2·0 m*M*	0	0	0	0

The following abbreviations are used: *R*—DDT, DDT-resistant gene on the second chromosome; *R*—*NS*, nicotine sulphate-resistant gene on the third chromosome; *S*, susceptible; *R*, resistant; PTU, phenylthiourea.

strain) and a strain susceptible to DDT and nicotine sulphate (*bw* ; *st ss*, multichromosomal mutant strain):

bw ; *st ss* ♀ × F_1 (*bw* ; *st ss* ♀ × Hikone-*R*31 ♂) ♂

The relation between the phenotypes and the number of surviving flies emerging from treated media was studied by using the larval test method[3]. Some of the results are shown in Table 1.

These results indicate that the mixed insecticide has a severe action even on flies exhibiting resistance to many kinds of insecticide. All strains of *D. melanogaster* were killed by exposing them to the mixture of the minimum amount of phenylthiourea which kills strains resistant to DDT and of the lowest amount of DDT which is enough to kill strains resistant to phenylthiourea (that is, susceptible to DDT).

Further experiments on the dosage from the point of view of population genetics are now in progress, and a more detailed report will be published elsewhere. I am greatly indebted to Prof. H. Kikkawa and Mr. M. Tsukamoto for supplying the strains resistant to insecticide.

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Fire-blight of Pear in England

THE presence of fire-blight of pear, an extremely destructive bacterial disease caused by *Erwinia amylovora* (Burrill) Winslow *et al.*, has recently been confirmed in England. This represents the first authenticated record of the disease in Europe.

Fire-blight is indigenous to North America and has been known for more than 150 years in the United States, where it is still a major factor limiting the successful cultivation of pear in certain areas. Elsewhere it occurs only in New Zealand; it appeared there about 1919 and in the next ten years spread to most fruit-growing areas of the Dominion. In addition to pear, the disease attacks apple and other related hosts, for example, quince, hawthorn, mountain ash, *Cotoneaster*, *Pyracantha* and various ornamental *Pyrus* spp.

The first intimation of the present outbreak was received during the late summer and autumn of 1957, from five fruit farms in the Maidstone, Wrotham and Rochester areas of Kent. Many pear trees of the variety Laxton Superb were then dying and on several others main branches had been killed by extensive cankers present on the branches and stems. In 1958 there was a further considerable spread of the disease in some of the affected orchards, and two completely new outbreaks were identified in the Rochester area.

Infection begins in the blossom, particularly the secondary blossom formed after the main spring flowering period. Diseased flower trusses turn black and the infection spreads rapidly into the branches causing a necrosis of the superficial cortical cells. The branches are eventually killed, the leaves wither and turn dark brown or black, and badly affected orchards then appear as if they have been swept by fire. The progress of the infection is halted towards the end of the season, but by this time it may have reached the trunk of the tree. Cracks now appear at the margins of diseased and healthy tissues and typical cankers are produced. In some of these cankers the bacteria survive the winter and renewed invasion of adjacent healthy tissues begins in the spring.

During the growing season, shoots and fruits may be attacked. These have an oily appearance at first but later they turn black in the same way as blossom. The fruits become wrinkled like a prune, and in humid weather they and the shoots exude a whitish bacterial ooze which turns amber after exposure.

The disease has been so destructive on Laxton Superb that one small orchard, consisting mostly of this variety, no longer has any commercial value. Conference, Dr. Jules Guyot and Bristol Cross have also been attacked, but so far only a few trees of these varieties have been involved. Williams Bon Chretien (*syn.* Bartlett), a variety often badly damaged by fire-blight in the United States, has so far remained virtually unaffected in the field, although it has shown little resistance in inoculation experiments.

Isolations made during this year from diseased branch, shoot, fruit and blossom tissues yielded the same organism, forming cream-coloured hemispherical colonies on a nutrient agar containing 5 per cent sucrose. The cross-infectivity of these isolates has been demonstrated in an extensive series of inoculation experiments. Symptoms on pear shoots and fruits were identical with those described for *E. amylovora*, the most characteristic feature being the production of white globules of bacterial ooze on the surface of infected tissues under humid conditions. Apple fruits, and apple and hawthorn shoots have also been successfully infected.

The pathogen is a Gram-negative peritrichous rod of the genus *Erwinia*, closely resembling authentic strains of *E. amylovora* in culture. The close affinity of the two organisms is also shown by tests with bacteriophages, isolated from soil in one of the diseased orchards by a method previously described[1]. Thus, among a wide range of *Erwina* and *coli-aerogenes* species examined, the phages were specific for the present pear isolates and *Erwinia amylovora*, including a strain of the latter tested at the New York State Agricultural Experiment Station, Geneva, U.S.A., by Dr. R. M. Gilmer.

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Autoradiographic Analysis on Agar Plates of Labelled Antigens from Rat Liver

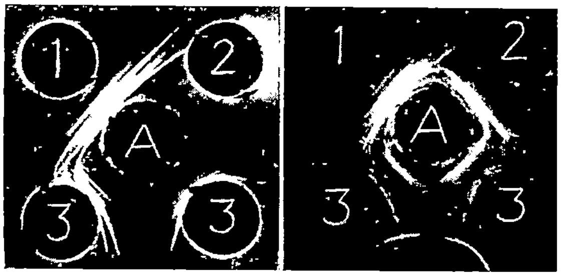
IN the study of protein metabolism it is often essential to be able to refer the incorporation of isotopic amino-acids to some individual type of protein, characterizable, for example, by means of a particular enzymatic activity or by its antigenic specificity[1]. As shown previously, soluble proteins derived from microscopic and submicroscopic fractions of liver cells can be characterized immunologically by means of precipitin reactions in agar plates[2]. In order to analyse some of the early pathways occurring in protein metabolism under various conditions, an attempt was then made to combine this method of protein identification with autoradiography in isotope incorporation experiments. A short account of the procedure and the results obtained are given in this communication[3].

Rat liver slices, about 0·3 mm. thick, were incubated for 30 min. in a Krebs–Henseleit medium in an atmosphere of 95 per cent oxygen and 5 per cent carbon dioxide. The medium, fortified with glucose, contained per ml. 0·015 µmole L-leucine-^{14}C (11·5 mc./mmole), 0·02 µmole of L-valine-^{14}C-(8·5 mc./mmole) and 0·065 µmole of DL-tyrosine-^{14}C (0·09 mc./mmole). The incubation was performed in tubes containing 40 mgm. of slices (fresh weight) per ml. of solution. After the incubation the slices were washed and homogenized in ice-cold 0·25 *M* sucrose. Microsomes and the soluble fraction were prepared by means of differential centrifugation[4]. The microsomal fraction was extracted with 0·4 per cent sodium deoxycholate[5]. Before further use, the solutions were diluted to contain approximately 4–6 mgm. protein/ml., determined according to Lowry *et al.*[6].

The immunological experiments were performed with antisera from rabbits, previously injected with total homogenate, microsomes or the soluble fraction ('supernatant') of rat liver. The mode of preparation of the antisera and the method of double diffusion in agar have been described previously[2].

After completion of the serological reactions the agar plates were freed from salts, amino-acids and excessive protein by prolonged washing with buffered saline and with water. After desiccation, the glass slides with the thin agar film on top were placed in contact with a photographic emulsion (Ilford, X-ray film, double coated) and left in the dark room for ten weeks. The autoradiographs were then developed in the usual way. Finally, the immunological precipitates were stained with azocarmin *B*[7], mounted with liquid plastics and the precipitation patterns recorded photographically.

Figs. 1 and 2 show the results of an experiment where the deoxycholate extract of microsomes was allowed to react with the various antisera mentioned above. Fig. 1 shows the normal spectrum of precipitates already described[2]. Fig. 2 presents the autoradiograph of the same experiment. Obviously, a high incorporation has been obtained of the amino-acids labelled with carbon-14 into the immunologically distinct proteins, extractable from the microsomes with deoxycholate. Moreover, the method has a good resolving power; the radioactivity is entirely concentrated to the different antigen–antibody precipitates, which show up almost as sharply in the autoradiograph as they do in the original plate.



Figs. 1 (left) and 2 (right). Precipitin reactions in agar-gel. Antigens diffusing from the central basin, antisera from the peripheral basins. Fig. 1 shows the print obtained by placing the dried agar film with the stained precipitates directly into the photographic enlarger. Fig. 2 shows the autoradiograph of the same plate. *A*, Deoxycholate extract of microsomes; 1, anti-microsomal serum; 2, anti-supernatant serum; 3, anti-total homogenate serum

As can be seen from Fig. 2, two strongly labelled precipitation lines were obtained in the reaction between the microsomal extract and the anti-supernatant serum. One of these also appeared between the extract and the anti-total homogenate serum. It is of great interest that the corresponding precipitates were scarcely visible in the original plate (cf. Fig. 1.) Although care must be taken in the interpretation of band-densities in the Ouchterlony reaction, there was good evidence to indicate that the amount of antigen in these heavily labelled precipitates was very low. Hence, it may be concluded that these two precipitates represent two groups of metabolically particularly active proteins.

The experiment described in this communication may be sufficient to illustrate the usefulness of a combination of autoradiography with immunological agar techniques for the qualitative and semi-quantitative analysis of protein metabolism in highly complex systems. Further studies on this method and its application are in progress.

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Coat-Colour and Longevity in Thoroughbred Mares

AUTHORITIES differ on the reality and consistency of differences in temperament and performance between horses of different colours[1,2]. Scheiermann[3], in a paper not available in Britain, has reported significant differences associated with colour in the working life of Rhenish horses. I have recently constructed life-tables for English thoroughbred mares, using the data contained in the General Stud Book, as part of a comparative study of the rates of actuarial ageing in mammals. Details of this work will appear elsewhere[4]: it was based on the 11 annual cohorts of brood mares foaled in 1860–64 and 1875–80 from the time of their entry at stud (average age 4 years). Of these 11 cohorts, 5 (1875–79) were scored for coat colour: of 1,271 mares composing them, 568 were bays, 181 browns, 262 chestnuts, 27 blacks, 5 greys, 3 roans and 2 grey roans, the balance being of doubtful or unstated colour. For comparison of the rarer coat-colours among thoroughbreds, further records of greys and blacks were taken by a search of the remainder of the Stud Book.

The mean and median expectations of life from 4 years of the various coat-colours, of the 1860–64 and 1875–80 samples, and of the individual cohorts making up the second of these, are given in Table 1. No separate life-table was calculated for brown mares, because of the probable diversity of coat-colours included in this description.

Table 1. Longevity and Survival by Coat-colour of Thoroughbred Mares

Group	n	$e_{x=4}$	V_e	Median
All colours :				
Foaled 1875	285	17·26	0·34	22·43
1876	245	17·65	0·21	22·43
1877	233	17·44	0·21	22·49
1878	248	17·49	0·30	22·15
1879	261	16·13	0·16	20·81
1880	221	16·01	0·18	21·81
1875–80	1,492	17·04	0·046	22·18
1860–64	1,250	17·31	0·044	22·07
Bays (1875–79)	568	16·68	0·08	22·03
Blacks (1854–1900)	358	16·53	0·15	21·95
Chestnuts (1875–79)	262	17·23	0·20	22·50
Greys (1845–1920)	200	15·57	0·28	20·43

Of the colour groups examined, only greys appear to diverge significantly from the mean expectations calculated for all mares, the difference being greater than those found between annual cohorts ($P < 0{\cdot}01$). Owing to the way in which the data were obtained, factors of selection cannot be entirely excluded ; the difference in the period from which lives of greys were drawn does not appear to be responsible for their shorter life, since there is no significant difference between the early and recent chronological halves of the sample. Greys have been selectively exported at most periods, compared with other coat-colours : they therefore show a rather higher percentage of losses to the record. Most of the reduction of their expectation of life is due to early deaths (< 10 years), the expectations of further life at 10 and 15 years being 10·96 and 3·85 years in greys as against 11·17 and 2·93 years in all mares of the 1875–80 sample. Causes of death were not recorded, and there is consequently no information about the prevalence of benign or malignant melanomata, to which grey horses of certain breeds are subject[5].

Grey thoroughbreds in the Stud Book are the progeny of a relatively small number of stallions compared with other colours, but none of these contributed sufficient progeny dying at a known age for the life-tables of his grey and non-grey fillies to be satisfactorily compared. Further studies of the Stud Book may indicate whether the apparent shortening of the life of grey thoroughbreds is real, and with what other factors it is correlated.

This work was undertaken during the tenure of a Nuffield Research Fellowship in Gerontology.

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Temperature Dependence of the Conductivity of Electrolyte Solutions

It has been known for some years that the ionization constant, K, of weak acids reaches a maximum value at a certain temperature T_m, which is defined by $T_m = \sqrt{(A_1/A_3)}$ if K is given by the following function of the absolute temperature[1] :

$$\ln K = -\frac{A_1}{T} + A_2 - A_3 T \qquad (1)$$

Here A_1 and A_3 are positive constants, while A_2 may be positive or negative. Equation (1) is valid for all kinds of solvents.

Kraus observed as early as 1900[2,3] that the conductance of non-aqueous salt solutions, when plotted against temperature, first increases, passes through a maximum and, thereafter, continues to decrease until the critical temperature of the solvent is reached. This phenomenon was ascribed by him to a continuous decrease of the dissociation constant for ion-pair formation with increasing temperature[4], which can only occur in solvents of a fairly high dielectric constant ε. (In these media the product εT, determining K, decreases as T increases.)

It is possible, however, to combine both phenomena and to give a more quantitative explanation of the conductance effect.

Combination of equation 1 with the fundamental electrochemical equations giving the relationship between ionic dimension (Stokes' law) and mobility, viscosity of the solvent and degree of ionization of the electrolyte, gives the following relation between the conductivity κ (in ohms^{-1} cm.$^{-1}$) of the solution and the absolute temperature :

$$\ln \kappa \approx -\frac{\dfrac{A_1}{2} + \dfrac{\Delta E}{R}}{T} + A_4 - \frac{A_3}{2} T \qquad (2)$$

in which ΔE denotes the activation energy of viscous flow, R the gas constant per mole and A_4 is another constant, independent of temperature.

As $\Delta E/R$ is positive, it follows from equation 2 that $\ln \kappa$ will reach a maximum value at the temperature :

$$T_m = \sqrt{\left\{\left(A_1 + \frac{2\Delta E}{R}\right)\Big/ A_3\right\}}$$

Thus it is clear that the effect observed by Kraus is a general phenomenon, valid for all electrolytes that are slightly ionized in the solutions considered.

By choosing a suitable solvent composition, the maximum in the conductivity can be brought into

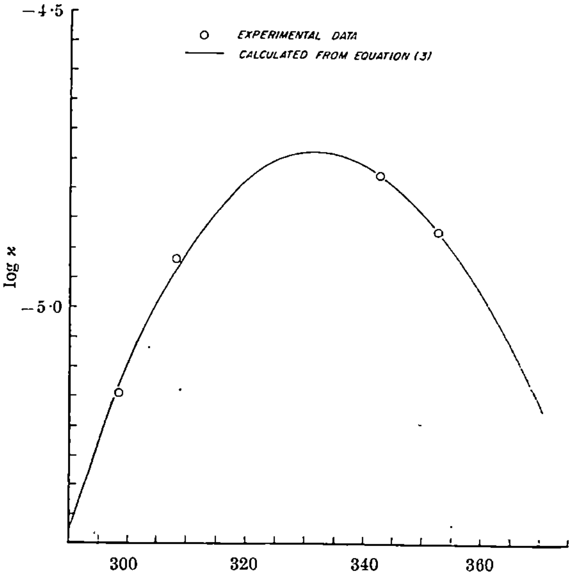

Fig. 1. Temperature dependence of the conductivity of 0·01 N acetic acid in water-dioxan (1 : 1 v/v)

a more accessible temperature region than Kraus observed. Examples are:

(1) 0·01 N acetic acid in water–dioxan (1 : 1 v/v), $T_m \approx 60°$ C.;

(2) 0·009 N perchloric acid in ethanol–benzene (21 : 34 v/v), $T_m \approx 60°$ C.

The first example is illustrated by Fig. 1. The conductivity curve drawn has been calculated from:

$$\log \varkappa = -\frac{11{,}760}{T} + 66{\cdot}14 - 0{\cdot}107\,T \qquad (3)$$

The coefficients in this equation have been determined from the experimental results.

Further details will be published elsewhere.

My thanks are due to Dr. E. A. M. F. Dahmen for his interest in this investigation.

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Change of Inclination of a Satellite Orbit

In a recent article, Merson and King-Hele[1] state that the inclination of the orbit of satellite 1957β decreased by about 0·15° during its life and that this could not be accounted for by any effect of the Earth's ellipticity. The decrease appears to be a consequence of the cross-wind produced by the Earth's rotation.

If α is the inclination, λ the latitude, β the angular distance from apex, Ω the angular momentum, T the period and D the length of a sidereal day, then the track crosses the lines of latitude at an angle $\sin^{-1}(\sin\alpha\sin\beta\sec\lambda)$. The angle between the track and the apparent wind is $\tan^{-1}\left(\frac{T}{D}\sin\alpha\sin\beta\right)$ and this produces a couple about the line of apices the magnitude of which is a fraction $\frac{T}{D}\sin\alpha\sin^2\beta$ of that of the retarding couple. For a satellite rotating in the same direction as the Earth and impulsively retarded at perigee:

$$\frac{d\alpha}{dt} = \frac{T}{\Omega D}\sin\alpha\sin^2\beta\,\frac{d\Omega}{dt}$$

For an orbit of small eccentricity T is proportional to Ω^3 so that:

$$\frac{d\alpha}{dT} = \frac{\sin\alpha\sin^2\beta}{3D}$$

Table 1

T (min.)	Age (days)	β (degrees)	$\sin\alpha \sin^2\beta$	$\delta\alpha$ (degrees)	α (calc.)	α (obs. ± 0·02)
103·8	0	−31	0·24	−0·015	65·321°	65·331°
101	53·5	−51	0·55	−0·027	306	309
98	98	−71	0·81	−0·034	279	272
95	132·5	−86	0·90	−0·036	245	232
92	152·5	−96	0·90	−0·030	209	204
89·5	160	−99	0·89		179	192

It is seen that the values found for the variation of α can be fitted to Merson and King-Hele's curve within the observational error; the variation is therefore predictable and gives no information not otherwise attainable.

In view of this there seems no point in elaborating the analysis to take account of the spread of the resistance around perigee and the effects of the following wind and the variation with height of the angular velocity of the atmosphere.

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Irregularities of Satellite Drag and Diurnal Variations in Density of the Air

A marked change in the slope of the period – time curves of *Sputnik* 2, *Sputnik* 3 and *Sputnik* 3 rocket has been reported, and from this it has been thought probable that the density of the air at a height of 220 km. increases considerably[1] somewhere between lat. 35° N. and 28° N.

An alternative explanation is that the sudden increase in drag is associated with the passage of the perigee from the night-side to the day-side of the Earth. In this case, the change is brought about chiefly by the precession of the orbital plane, instead of by the rotation of the perigee in the orbital plane. As the orbital plane rotates, the perigee is taken from the night-side to the day-side of the Earth, into air that has just been carried through the day-time side by the Earth's rotation; this being in the opposite sense to that of the orbital plane.

As the orbital plane precesses about ten times faster than the perigee rotates in the orbital plane, this explanation seems to account for the suddenness of the change more easily. An appreciable arc of the orbit near perigee could pass from the night-side to the day-side of the Earth in less than a day at the time of year when the terminator is at its smallest inclination (1·4°) to the orbital plane. At its greatest inclination (48°) to the orbital plane, the change-over would take about ten days.

For *Sputnik* 2, it is found that perigee passed into sunlight on December 23, 1957, the angle between orbit and terminator being nearly maximum. The observed change in slope of the period–time curve occurred over an interval of several days centred at about December 30. For *Sputnik* 3, rocket and satellite, the perigees passed into sunlight on July 13 and 14, 1958, the angle between orbit and terminator being nearly a minimum, whereas the observed changes in the slope of the period–time curves appear in the region of July 20 and 24 respectively. The correspondence is very close, and the consistent difference of about a week would be reduced if the calculated dates were based on a solar zenith distance of slightly less than 105°, which is the zenith distance of the horizon as seen from a height of 220 km. When the Sun's zenith distance increases beyond about 85°, the heat input would fall off rapidly due to the increasing length of path through the atmosphere. Assuming the cooling process to be of the same order of rapidity, so that 85° is the solar zenith distance at which the change occurs instead of 105°, the calculated dates become December 29, 1957, for *Sputnik* 2 and July 20 and 22, 1958, for *Sputnik* 3, rocket and satellite.

Other dates on which the perigees of the Russian Earth satellites passed or will pass into daylight (solar zenith distance less than 85°) are March 19, 1958, for *Sputnik* 2, October 24, 1958, for *Sputnik* 3 rocket, and October 30, 1958, January 30, 1959, for *Sputnik* 3 satellite.

The dates on which the perigees passed or will pass out of daylight (solar zenith distance greater than 85°) are February 4, 1958, for *Sputnik* 2, June 11, September 6 and December 12, 1958, for *Sputnik* 3 rocket and June 9, September 9 and December 14, 1958, for *Sputnik* 3 satellite. The existence of a sharp *fall* in air density at perigee on these dates depends on the rate of heating of the night air as it passes into sunlight. This may be so slow that the change in the slope of the period – time curve is not detectable against the fluctuations due to changes in the aspect of the rocket.

Clearly, more observations are needed before variations in density in the upper atmosphere and the processes causing them can be fully understood. The solar heating which appears to be responsible for the increase of density at 220 km. probably occurs at much lower heights, perhaps in the region of 100 km., and the expansion of the air at this level lifts the atmosphere above. The use of spherical satellites would eliminate the fluctuations in the period – time curve due to changes of aspect of the rocket, and allow variations in density to be studied with very much greater precision. It should then be possible to follow tidal variations of air density. These have not so far been picked out and are largely unknown at great heights.

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Secondary Oscillations in an Equatorial Atlantic Deep-Sea Core

PRIMARY oscillations, corresponding to long-period changes in temperature in the upper layer of the sea, have been reported in long cores from Equatorial and North Atlantic, the Caribbean and Mediterranean Seas[1-3]. These changes, apparently the equivalent of glacial and interglacial periods, have been followed by: oxygen-18/oxygen-16 measurements on selected species of Foraminifera which deposit their tests in the upper layer of the sea; determining the proportions of planktonic Foraminifera characteristic of warm, temperate and cool waters; carbonate analyses and grain size determinations.

Cores from Atlantic abyssal plains are unsuitable for determining these changes because in these environments sediment is transported on the deep-sea floor from higher to lower levels. An undisturbed chronological sequence of sediments is frequently found in cores from the flat tops of isolated knolls, because they are outside the zone of turbidity currents.

Investigations have been made to determine whether undisturbed cores retain records of short-period temperature oscillations. A continuous series of ½-cm. sections have been taken from a core collected by the Swedish Deep-Sea Expedition (1947–48), from the top of a knoll in 1° 10′ N., 19° 50′ W. In this core the ratio of the sinistral to dextral tests of *Globigerinoides sacculifera* frequently changes by 20 per cent in ½ cm. It would therefore seem unlikely that the original sedimentary sequence has been appreciably disturbed by benthonic organisms.

Secondary carbonate oscillations, tentatively ascribed to short-period changes in temperature in the upper layer of the sea, were found superimposed on long-period changes[4]. It is unlikely that these oscillations are due to other causes because similar changes have now been found by determining in this core the annual rates of accumulation of: (1) calcium carbonate; (2) nitrogen; (3) fractions coarser than 500 and 250μ; (4) *Globorotalia menardii menardii*; and (5) *Globigerinoides sacculifera*. In collaboration with Dr. C. Emiliani and Mrs. T. Mayeda, oxygen-18 determinations have been made on the tests of *Globigerinoides sacculifera* isolated from 33 sections. There is a general parallelism between isotopic temperatures and rates of accumulation of calcium carbonate. It is, however, impossible to show by this technique whether the secondary carbonate oscillations are or are not reflexions of changes in temperature, because its accuracy is only about ± 1° C.

The age of the mid-point of each section, as well as its age range, was determined from the weights of titanium and iron in unit-area columns through each section. There is a variety of evidence which suggests that the rates of accumulation of these elements have not varied during the time interval represented by the core, and that there has been no post-depositional movement.

Some of the results, for the period 14,500 B.C.–4500 B.C., are shown in Fig. 1. There is at many points a sympathetic relation between the various methods. The rate of accumulation of *Globorotalia menardii menardii* was $\sim 0{\cdot}005$ μgm./cm.^{2}/yr. during the maximum phases of the last glaciation. The

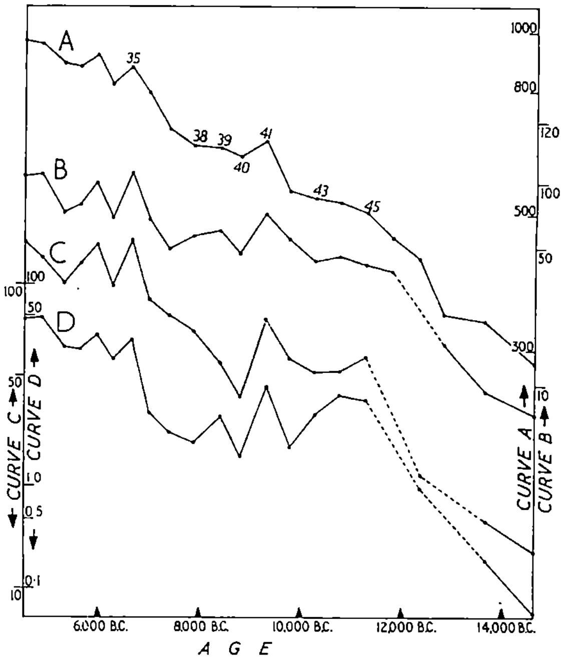

Fig. 1. Rates of accumulation (μgm./cm.^{2}/yr. on a log scale) of: (*A*) calcium carbonate; (*B*) fraction coarser than 500μ; (*C*) *Globorotalia menardii menardii* plus *Globigerinoides sacculifera*, and (*D*) *Globorotalia menardii mendardii*. Section Nos. are given on curve *A*

maximum rate, ~ 159 μgm./cm.²/yr. was attained in about A.D. 1200. Confirmation is therefore given to Schott's hypothesis[5] that in the equatorial Atlantic this species was rare during the maximum phase of the last glaciation.

The reliability of all the methods of determining past changes in temperature is subject to various conditions—for example, methods (3), (4) and (5) are affected by changes in the degree of fragmentation. Methods (4) and (5) are invalidated if the investigated species replaces, or is replaced by, another species characteristic of warm water. The sharp rise in the rate of accumulation of *Globorotalia menardii menardii* between section Nos. 43 and 45 (Fig. 1*D*) is apparently related to this effect, because there is no notable increase in the combined rates of accumulation of *Globorotalia menardii menardii* and *Globigerinoides sacculifera* (Fig. 1*C*).

Thirty of the minor changes in the annual rates of accumulation of calcium carbonate may be correlated with secondary climatic changes in Europe and North America. For example, the oscillation at 9200 B.C. (section No. 41) is correlated with the well-established climatic amelioration in pollen zone II (the Alleröd oscillation). The radiocarbon age of zone II*b* at Wallensen, Germany, is 9200 B.C.[6], and its equivalent in eastern Wisconsin—the Two Creeks interval—has been dated by Arnold and Libby as 9450 B.C.[7]. The temporary return to cold in zone III is represented by section Nos. 40–39 (8750 B.C.–8350 B.C.). In Denmark the ages of the lower and upper limits of the Younger Dryas are, respectively, 8900 B.C. and 8350 B.C.[8], while its equivalent in eastern Wisconsin—the Valders glacial maximum—is dated 8700 B.C.[9].

The period of increasing temperature, 7850 B.C. (section No. 38)–6600 B.C. (section No. 35), apparently corresponds in Europe to the retreat of ice from the central Swedish moraines, and the Yoldia marine transgression in the Baltic. In the southern North Sea peat beds, containing a Maglemose harpoon-head[10], were apparently flooded after 6450 B.C.[11]. It is of interest to report that a small ridged flake of grey flint (British Museum, 1957, 663) was collected south of the Dogger Bank (53° 50·5′ N., 1° 40·0′ E.) in July 1957 by Lieut.-Commander C. J. de C. Scott while in command of H.M.S. *Shackleton*. Dr. K. P. Oakley considers that this could be Upper Palæolithic or Mesolithic.

In North America there is a period of increasing warmth marked by the rapid retreat of the ice from the Valders moraines in Wisconsin to those near Cochrane, Canada[12].

In view of the apparent correlation between secondary changes in the upper layer of the equatorial Atlantic and climatic changes in Europe and North America it is desirable, on climatological grounds, to discover whether similar oscillations occurred in other oceans. Cores from the Indian Ocean, collected by the John Murray Expedition (1933–34) and housed in the British Museum (Natural History), although unsuitable for detailed work of this nature, clearly indicate past temperature changes in the upper layer of this ocean. It is therefore hoped that when the preliminary programme for work in the Indian Ocean suggested by the Special Committee on Oceanic Research[13] is reviewed, consideration will be given to the desirability of collecting undisturbed cores from suitable sedimentary environments, and the necessity of training research students in the various techniques.

J. D. H. WISEMAN

British Museum (Natural History),
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Sept. 25.

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Polarographic Study of Acid-Base Reactions of the Tropylium Ion

A POLAROGRAPHIC study of the tropylium ion $(C_7H_7^+)$ in unbuffered media[1] did not permit any quantitative interpretation of the acid-base phenomena at the surface of the mercury dropping electrode. We therefore followed the reduction of the tropylium ion in well-buffered media. At concentrations lower than about 0·00015 *M* one irreversible reduction wave was observed. The height of this wave decreased with increasing *p*H in the form of a dissociation curve (Fig. 2) with $pK' = 5{\cdot}64$ at $t_1 = 3{\cdot}3$ sec. The kinetic current at higher *p*H values is limited by the rate of formation of the reducible tropylium cation from electro-inactive

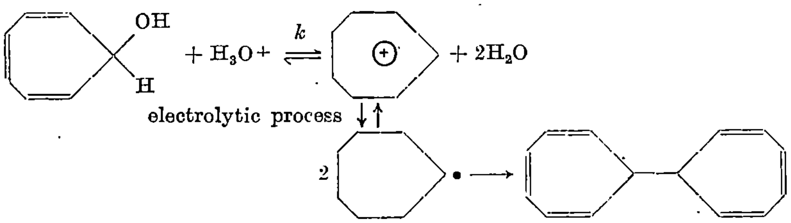

Fig. 1

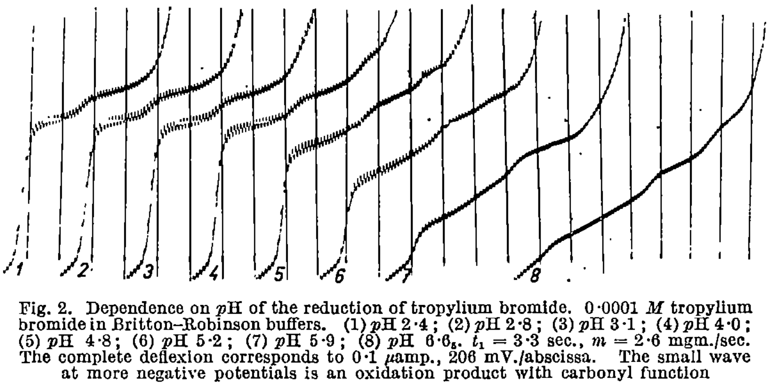

Fig. 2. Dependence on *p*H of the reduction of tropylium bromide. 0·0001 *M* tropylium bromide in Britton–Robinson buffers. (1) *p*H 2·4; (2) *p*H 2·8; (3) *p*H 3·1; (4) *p*H 4·0; (5) *p*H 4·8; (6) *p*H 5·2; (7) *p*H 5·9; (8) *p*H $6{\cdot}6_5$. $t_1 = 3{\cdot}3$ sec., $m = 2{\cdot}6$ mgm./sec. The complete deflexion corresponds to 0·1 μamp., 206 mV./abscissa. The small wave at more negative potentials is an oxidation product with carbonyl function

tropyl alcohol, which is present in the solution and is brought by diffusion to the surface of the mercury electrode.

The reduction proceeds by a one-electron step to a radical, with subsequent formation of ditropyl, as in the reduction by zinc[2]. The formation of the dimer was proved[3] by the shift of the half-wave potential with increasing tropylium bromide concentration. The half-wave potential at pH lower than 4·6 is independent on the pH ; at higher pH it shifts to more negative values according to the equation $E_{1/2} = -0{\cdot}25 - 0{\cdot}040\ p\mathrm{H}$ (standard calomel electrode). The slope of the curves is 0·040. All the phenomena observed are consistent with the mechanism indicated in Fig. 1.

Neither the character of the dissociation curves nor the pK' values are affected by the buffer components, by the pyridinium ions or by the ionic strength. Using the equation derived by Koutecký[4] and the value $pK = 4{\cdot}6$, determined by titration, the rate constant for the formation of tropylium ion was calculated as $k = 2 \times 10^6$ l. mole^{-1} sec.$^{-1}$.

At concentrations of the tropylium ion higher than about 0·001 M, three types of adsorption processes were observed. Using the value for the lowest adsorption wave, the surface-area (S), covered by one reduced seven-membered ring at the surface of the mercury drop, was calculated by Brdička's equation[5] as 29 A.^{2}. Using covalent radii and bond distances[6], S was calculated as 22 A.^{2}. Adsorption processes were studied using i–t curves, $\bar{i}$–t curves, single-sweep polarography, oscillographic polarography, etc. Detailed results will be published elsewhere.

We are indebted to Mr. C. R. Ganellin (Queen Mary College, University of London) for the sample of tropylium bromide.

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Sept. 10.

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Origin of Time-dependent Organization in a Micelle Series

The question of physical equilibrium in homogeneous solution may be stated as follows : At what stage of molecular complexity can a solute exist in non-equilibrium for times which are very long in relation to the scale of molecular processes ? The complex linear micelles formed by the interaction of naphthol and a quaternary soap are able to exist[1] and contrary to expectation[2], the simple micelles formed by the same soap alone[3]. The purpose of this communication is to show at what point in a homologous series such persistent non-equilibrium arises.

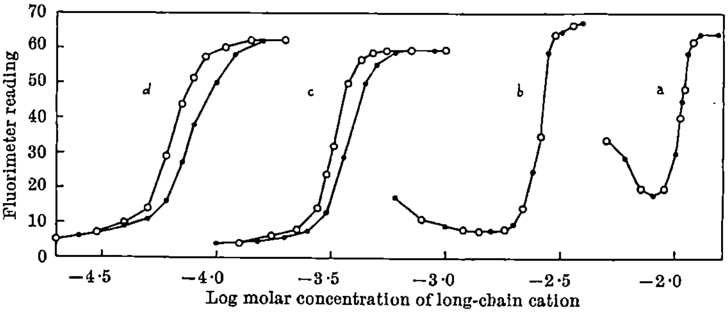

Fig. 1. Use of fluorescent dye in discriminating between different states of a cationic soap solution. Fluorescence of μM dichlorofluorescein as a function of concentration of four cationic soaps at 25° C. *a*, C12 trimethyl ammonium bromide in 4 mM sulphate ; *b*, C14 in 0·24 mM sulphate ; *c*, C16 in 0·05 mM sulphate and *d*, C18 in 0·024 mM sulphate. ○, Stock soap added to diluted salt ; ●, stock salt added to diluted soap

The compounds chosen were the C12, 14, 16 and 18 paraffin-chain trimethyl ammonium bromides, in aqueous solution around the critical micelle concentration, with a low concentration of sodium sulphate to develop the non-commutative property. This meant that the chemical potential could depend on the order in which the components were added (from relatively strong stock solution) as well as on the final composition. Sulphate was used rather than halide to minimize supersaturation[4]. Non-equilibrium was detected by fluorescence quenching, using dichlorofluorescein as the marker. The method depends on the sensitiveness of the dye/micelle adsorption complex to chemical potential ; full details are being submitted elsewhere together with a theory based on accepted principles.

In numerous experiments at 25° C. it was found that solutions of the C12 and C14 soaps were always completely defined by their composition, so that all the experimental points fell on a single curve (Fig. 1). This was not true for the others ; the curve split into two parts, the upper part referring to solutions in which sulphate had been added first, and the lower to those in which soap had been added first, as predicted by theory. The possibility of superimposable organization in homogeneous solution seems, therefore, to arise at a very early stage in molecular complexity, in micelles of a paraffin-chain salt with 16 or possibly 15 carbon atoms. Because of water-structure effects with quaternary compounds[4,5], not apparent with anionic ones, the critical chain-length is probably a little greater for the latter.

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Aug. 29.

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FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, December 1

Royal Society (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Anniversary Meeting.

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. R. S. Peters: "A Defence of Aristotelianism in Psychology".

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. T. J. Hawker: "Some Industrial Applications of Magnetic Power".

University of London (in the Physiology Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Z. M. Bacq (University of Liège): "Substances which Protect Against Ionizing Radiations"* . (Further lecture on December 3.)

Royal Institute of Chemistry, London Section (joint meeting with the London Section of the Society of Chemical Industry, at the Society of Chemical Industry, 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. J. L. Edgar: "The Production of Petrochemicals in Holland".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. A. R. Akester: "Saharan Survey".

Tuesday, December 2

University College (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. S. Feldberg: "Some Physiological Aspects of General Anæsthesia".*

Institution of Mechanical Engineers, Education Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Planning of Mechanical Engineering Teaching Laboratories".

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Discussion of Three Research Papers published in the *Journal of Applied Chemistry*.

Wednesday, December 3

University of London (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. R. I. S. Bayliss: "Laboratory Investigations in Endocrinology".*

Society for Analytical Chemistry (joint meeting with the Association of Public Analysts, at the Wellcome Building, Euston Road, London, N.W.1), at 3 p.m.—Symposium on "Food Analysis"

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Discussion on the Report of the Committee on the Supply of and Demand for Statisticians.

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. G. W. Lee: "The Work of the British Coke Research Association".*

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. J. F. Hutton: "Flow Properties of Distillates at Low Temperatures: a Review"; Mr. H. Strawson: "The Pumpability of Aviation Turbine Fuels at Low Temperatures".

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. O. E. Lowenstein, F.R.S.; "Sensory Function and Qualitative Information".* (Further lectures on December 4 and 5.)

Society of Chemical Industry, Plastics and Polymer Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. D. A. Boyle, Mr. W. Simpson and Dr. J. D. Waldron: "The Characterization of Short Chain Branches in Hydrocarbon Polymers".

Radar and Electronics Association (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7 p.m.—Dr. R. L. F. Boyd: "Exploration of the Upper Atmosphere by Rockets and Satellites".*

Thursday, December 4

Royal Society (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m.—Discussion on "The Effect of Environment Upon Molecular Energy Levels" opened by Dr. H. W. Thompson, F.R.S.

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Exhibition Meeting.

Institute of Refrigeration (at the Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Mr. G. L. H. Bird, Dr. J. C. Fidler, Mr. W. B. Gosney and Colonel H. Randal Steward: Review of the Moscow Meetings of the International Institute of Refrigeration.

Institution of Electrical Engineers (in conjunction with the British Nuclear Energy Conference, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. D. W. Fry: "A Review of Work towards Nuclear Energy from Controlled Thermonuclear Reaction".

Physical Society, Acoustics Group (in the Physics Department, Imperial College, London, S.W.7), at 5.30 p.m.—Dr. P. T. Haskell: "Insect Acoustics".

Royal Anthropological Institute of Great Britain and Ireland (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Prof. C. von Fürer-Haimendorf: "Monastery and Village among the Sherpas of Nepal".

Royal Institution, Library Circle (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Dr. A. S. C. Lawrence: "Sir James Dewar and the Royal Institution".

Society of Chemical Industry, Microbiology Group (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Meeting on "Preparation of Vaccines". Dr. P. W. Muggleton and Miss J. P. Farmer: "Preparation and Standardization of Freeze-Dried B.C.G. Vaccine". Dr. J. A. Dudgeon: "Preparation of Viral Vaccines".

Polarographic Society (at "The Duke of York", 8 Dering Street, London, W.1), at 7 p.m.—Informal Discussion Meeting on "Some Polarographic Problems Encountered in the Food Industry" introduced by Dr. T. L. Parkinson.

Royal Institute of Chemistry, London Section (joint meeting with the Battersea College of Technology Chemical Society, at the Battersea College of Technology, Battersea Park Road, London, S.W.11), at 7 p.m.—Prof. A. R. Ubbelohde, F.R.S.: "Melting Mechanisms of Ionic Crystals".

Thursday, December 4—Friday, December 5

British Institute of Radiology, incorporated with the Rontgen Society (at Church House, Westminster, London, S.W.1)—Annual Congress and Exhibition.

Friday, December 5

Institution of British Agricultural Engineers (at 6 Buckingham Gate, London, S.W.1), at 2.15 p.m.—Paper: "How Far are British Tillage and Harvesting Machines Meeting Overseas Conditions?" (Informal Meeting).

University of London (at Senate House, London, W.C.1), at 5.30 p.m.—Dr. W. H. Glanville: "Motorways".*

Society of Chemical Industry, Pesticides Group (together with the Agriculture Group and the Fine Chemicals Group, at 14 Belgrave Square, London, S.W.1), at 5.45 p.m.—Joint Meeting on "Gibberellic Acid". Dr. P. W. Brian: "The Effects of Gibberellic Acid on Plant Growth"; Dr. B. E. Cross: "The Chemistry of Gibberellic Acid".

Institution of Mechanical Engineers (in conjunction with the British Nuclear Energy Conference, at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. K. G. Mantle, Mr. N. Marshall and Dr. P. J. Palmer: "An Experimental Investigation into the Stress Distribution in a Band Reinforced Pressure Vessel".

Society of Dyers and Colourists, London Section (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Dr. J. L. Stoves: "Dyeing of Furs".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Richard van der Riet Woolley, F.R.S.: "Stellar Motions and the Structure of the Universe".

Saturday, December 6

Association of Agriculture and the British Agricultural History Society (at the Institute of Education, University of London, Malet Street, London, W.C.1), at 11 a.m.—Agricultural History Conference.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Senior Lecturer in Radiochemistry in the Department of Chemistry and Biology, College of Technology, Liverpool—The Director of Education, City of Liverpool Education Committee, 14 Sir Thomas Street, Liverpool 1 (December 5).

Assistant Librarian (with a good honours degree) in the Science Libraries—The Registrar, The University, Liverpool (December 6).

Assistant Physicist (with a good honours degree in physics) in the Physics Department of the Sheffield National Centre for Radiotherapy—The Secretary, Sheffield Regional Hospital Board, "Broom Cross", Tree Root Walk, Sheffield 10 (December 6).

Lecturer (with a good honours degree in mining engineering and postgraduate research and/or industrial experience) in Mining Engineering—The Registrar, King's College, University of Durham, Newcastle-upon-Tyne (December 6).

Chair of Metallurgy—The Registrar, The University, Manchester (December 8).

Scientific Officer, Grade 3 (with an honours degree in metallurgy, chemical engineering or chemistry, or other academic qualifications and research achievements considered the equivalent) at the Weapons Research Establishment of the Department of Supply, near Adelaide, South Australia, for research into high-temperature materials with special reference to rocket motors and high-velocity rocket missiles—The Senior Representative (AV/9/12), Department of Supply, Australia House, Strand, London, W.C.2 (December 8).

Lecturer or Assistant in Organic Chemistry—The Registrar, The University, Leeds (December 15).

Post-Doctoral Research Fellow in the Department of Fuel Technology and Chemical Engineering, to direct and carry out research on the laws of smoke formation and elimination with all types of fuel—The Registrar, The University, Sheffield (December 15).

Micro-Biologist (with a good honours degree in botany or agricultural botany) at the Welsh Plant Breeding Station, for work associated with the breeding of new strains of clover—The Registrar, University College of Wales, Aberystwyth (December 20).

Senior Lecturer or Lecturer (Grade I or II) in Geology initially in the Geography Department, University College, Ibadan, Nigeria, to develop teaching of geology in the Faculty of Science and to assist with geology teaching for the Faculty of Agriculture—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 22).

Lecturer in the Department of Zoology, and an Assistant in the Department of Zoology—The Secretary, The University, Edinburgh (December 27).

Fellow (with previous research experience in either radio astronomy or astronomy) in Radio Astronomy in the Division of Radio Physics, Commonwealth Scientific and Industrial Research Organization, Sydney, to take part in an active research programme in some aspect of radio astronomy—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 780/194 (December 31).

Senior Lecturer or Lecturer in Agricultural Botany, a Lecturer in Inorganic Chemistry, a Lecturer in Mathematics, and Lecturers (2) in Botany at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 31).

Lecturer (electrical engineer or physicist) in Electrical Engineering—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (January 13).

Chair of Agricultural Chemistry—The Registrar, University College of Wales, Aberystwyth (January 17).

Senior Fellow or Fellow (with qualifications, interests and experience in some physico-chemical aspect or aspects of biochemistry) in the Department of Physical Biochemistry, John Curtin School of Medical Research, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 19).

Assistant, Grade B (graduate, preferably with teaching and/or industrial experience) in Physics, to teach up to B.Sc. and H.N.C. standard—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford.

Assistant Lecturer, Grade B (with a degree or equivalent qualification, and preferably industrial and/or research experience) in Chemistry—The Principal, Medway College of Technology, Horsted, Maidstone Road, Chatham, Kent.

Assistant Lecturer, Grade B (with an honours degree in geography and teaching experience), in Geography, preferably with Social Studies as subsidiary subjects—The Principal, Coventry Technical College, Coventry.

Biochemist in the Endocrinology Laboratory—The House Governor, Royal Marsden Hospital, Fulham Road, London, S.W.3.

Bradford City Council Research Scholar (honours graduate in chemistry or biochemistry) in the Department of Chemical Technology, to work on some aspect of protein chemistry related to the keratins—The Registrar, Institute of Technology, Bradford 7.

Experimentalist (physical or inorganic chemist, preferably with a degree) in the Electromagnetic Separation Team investigating the chemistry of most elements including plutonium, using many physical and engineering techniques—The Group Recruitment Officer (1249/34), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Berks.

Lecturer or Senior Lecturer in Metallurgy in the Department of Mechanical Engineering—The Registrar, Royal Technical College, Salford 5.

Lecturers and Senior Lecturers (with an honours degree in engineering or equivalent qualification) in the Department of Mechanical Engineering—The Registrar, Royal Technical College, Salford 5.

Librarian (woman, with a degree in biology or zoology)—The Secretary, Bureau of Animal Population, The University, Botanic Garden, Oxford.

Research Physicist (preferably with experience in the use of ultra-high vacuum systems or in the chemical physics of surfaces) in the Department of Physics, for work involving electrical measurements applied to the study of surface contamination processes on semiconductors—The Professor of Physics, University of Reading, Physics Research Laboratories, Upper Redland Road, Reading, Berks.

Scientific Officer (Chemist) (with a good honours degree in chemistry, postgraduate experience in food analysis, and preferably a knowledge of fumigant and insecticide analysis) in the Department of Marketing and Exports, Federation of Nigeria, to undertake research into problems associated with the storage of oil seeds and other food crops with particular reference to insect infestation with the object of evolving methods for reducing losses—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.153/14/05.

Scientific Officer (with a good honours degree in botany or agriculture, and preferably some postgraduate experience in agronomic methods and a knowledge of field experimentation statistics) with the West African Maize Research Unit, Nigeria, to take charge of agronomic work with maize and to conduct trials in maize husbandry—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.197/375/02.

Senior Agronomist (with a university degree in agriculture or a degree in natural science with a postgraduate diploma in agriculture and experience in field experimental studies, preferably with perennial tree crops) at the West African Cocoa Research Institute, Ghana, to take charge of the Agronomy Section and co-operate with senior specialist officers in the field of experimental work of the Institute—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.197/200/010.

Senior Histological Technician—Prof. H. P. Gilding, Department of Physiology, Medical School, Birmingham 15.

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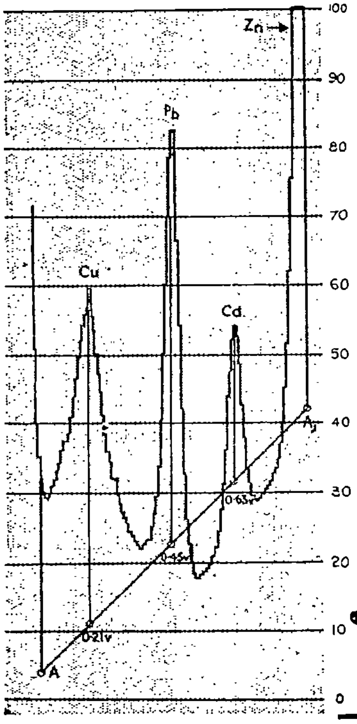

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HUMAN RELATIONS IN INDUSTRY

THE final report of the Joint Committee on Human Relations in Industry* covers the three ıars from the issue of the Committee's first report March 1954 until, on the termination of the Con-tional Aid Scheme on March 31, 1957, the Joint ımmittee, like that on Individual Efficiency in .dustry, was disbanded. Eventually, in November '57, the Council for Scientific and Industrial esearch set up a permanent Human Sciences Com-ittee to advise on future support by the Department Scientific and Industrial Research for research in ese sciences, especially that relating to the design equipment, training and human relations in dustry. The work carried out by both Joint Com-ittees is briefly reviewed in reports which are here blished under one cover ; but the main interest of th reports lies in their discussion of policy and rvey of the general position of research in this ld.

The period of office of the two Committees has tnessed a real development of research in the ld of human relations in industry and a big growth industrial interest in such research. Both oppor-nities and needs are now more clearly understood, d although the work of both Committees was minated, and probably excessively so, by the funds ıde available under the Conditional Aid Programme d derived from United States economic aid, which t to research being concentrated on the study of oblems arising out of practical situations, the Com-ttee on Human Relations in Industry believes that luable lessons can be learnt from its experience. w lines of study, for example, were opened up and w ideas introduced into academic thinking. The mation of new research groups was prompted and ilitated, and these groups and many recently alified workers have been attracted to the study human problems in industry.

Nevertheless, the Committee points out that such ditions can lead to distorted effort, and those es of research which add to underlying knowledge t are only indirectly relevant to immediate prac-al purposes are liable to be neglected. Studies of s character provide the foundation essential to rt-term investigations of practical problems, and Committee takes the view that future arrange-nts for financing social research from public funds uld provide for work of a basic, long-term char-er. It does not, indeed, appear from these reports t this undue reliance on Conditional Aid Funds , in fact, to the promotion of projects of dubious ue, as was suggested at the time (cf. *Nature*, 174, 1954) ; but it is scarcely to the credit of Britain that in accepting the generous offer of the United States this lack of balance should have been allowed to develop through failure to supply the further funds which already in 1954 were recognized as needed. The newly established Human Sciences Committee intends to encourage both basic and applied research for the promotion of the growth of psychology and sociology, and to make further contributions to the solution of the practical problems of industry and society ; but Government support could equally well have been used five years ago to check the obvious tendency of Conditional Aid Funds to divert effort from such fundamental research.

The Committee on Human Relations in Industry recognizes that fundamental and applied research in this field are closely related. Some of the best projects it has sponsored have combined an attack on practical problems with penetration of underlying theoretical issues. It suggests that it is characteristic of social science that the best results come from those who are able to operate at both the practical and theoretical levels ; but nevertheless, the Committee is convinced that opportunities must be available for research workers of high calibre to pursue fundamental studies.

Nor is this the only problem of balance. It is equally important to correct the piecemeal character of much social research in industry, and ensure that the right targets are selected. The Committee sought to meet the criticism from industry that the problems studied by academic social scientists are trivial, or of past, rather than present, interest, and that the priorities are wrong, by going to industry for suggestions ; some research arising from suggestions originating from industry was included in its programme. Its experience, however, led to the conclusion that academic research groups readily welcome suggestions from industry concerning the problems that merit study ; any reticence on their part is usually related to difficulties in arriving at a research method and plan that will meet scientific requirements and in finding competent research workers. Further, to develop a bare suggestion for research into a realistic research project requires much further discussion and detailed formulation, and, in consequence, a considerable amount of effort from the industrial organization responsible for the suggestion.

To secure the contribution of both the research group and the industrial organization is thus not a simple proposition ; but the Committee is convinced that industrial needs will only be properly reflected in the research programmes of academic research groups if this joint approach is widely adopted. Real progress depends on individual research groups finding ways and means of associating industry more closely with their work, not only in its execution and

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Department of Scientific and Industrial Research. Final Report he Joint Committee on Human Relations in Industry 1954–57 Report of the Joint Committee on Individual Efficiency in stry 1953–57. Pp. vi+44. (London: H.M. Stationery Office, .) 3s. net.

in the application of its results but also in the choice of the problems to be investigated.

Nor is such a balanced effort solely a matter of collective judgment on the part of those sponsoring the research. Administrative arrangements can also be an important factor, in that as these at present stand there is no point at which both the funds available and the whole range of projects to be considered are known. The Human Sciences Committee will not be effective unless public financial support for social research programmes has much more continuity than in the past. A settled policy of support is needed and *ad hoc* administrative arrangements should be terminated.

Before considering the Committee's comments on the ways in which financial assistance should be given, there is a further factor to be considered which bears on this question of continuity. The main obstacle to the healthy growth of social research in industry remains the shortage of trained people. The Committee admits that only a few project leaders capable of planning and directing research have emerged as a result of the work done during the past three years. This crucial deficiency is attributed to the lack of reasonable career prospects; for this reason, research organizations are faced with a steady drain to industry of their best people just when they promise to be most useful—as senior scientists competent to take immediate charge of research projects under the general supervision of the director of research.

Since many of the social research groups are built around one senior person, whose transfer to industry means the disintegration of the group, the Committee concludes that a main object of future public support should be to create a number of stable research groups of viable size, characterized by a higher ratio of senior to junior staff, so as to reduce vulnerability as well as provide adequate supervision, and by a sufficient size to provide young research workers with an intellectually stimulating environment in which to learn the craft of research. Moreover, such a step should contribute towards establishing the independence of social research workers, a matter on which the Committee also lays great stress. It considers that Britain is fortunate in that social research workers have been able to maintain the impartiality and independence of their scientific role, but its continuance depends on ability to gain and retain confidence. It is essential here that social research workers should recognize that the choice between different social objectives is a matter for those directly concerned in the industry, and not for them in their scientific capacity.

The Committee distinguishes three types of research groups which require financial assistance. For those seeking to enter the field but possessing neither the experience nor the proved competence to focus their research interests immediately and to formulate an appropriate research method, assistance should be limited to a period of two or three years. The work of the more mature groups, with well-developed industrial contacts, is probably best su
ported on the basis of individual projects over a
agreed period. But neither group can develop t
measure of stability in personnel and the long-ter
scientific strategy needed for fundamental research
its finance is wholly *ad hoc*. Besides these tw
groups, the Committee visualizes grants by t
Department of Scientific and Industrial Research
the Medical Research Council to enable the unive
sities or independent research institutes to crea
stable research units for the study of subjects
joint interest.

Apart, however, from indicating that the unive
sities or independent research institutes wou
be expected normally to provide the necessa
foundation of uncommitted, long-term support, a
emphasizing the importance of social research
industry being recognized as an established universi
interest to be supported by normal university fund
the Committee does not seem to consider the implic
tions of such a system or how co-ordination a
balance are in practice to be secured. The Committ
does not attempt to re-open the question whether
not a Social Science Research Council should now
established, and it could scarcely have been expect
to ask whether the Department of Scientific a
Industrial Research or the Medical Research Coun
is the most appropriate body either to co-ordina
social science research or to distribute public fun
for such research. These, however, are the critic
questions, and they require further discussio
especially in the light of evidence that the Depa
ment of Scientific and Industrial Research and ev
the Lord President's office as at present constitut
are unable to function effectively in that way, a
also in relation to the wide issues on the control
expenditure on research raised by the recent repo
of the Select Committee on Estimates.

In the light of the evidence submitted to th
Committee, it seems essential that the method
distribution of research grants and the way in whi
expenditure is to be controlled and co-ordinat
should be carefully considered before any ne
administrative arrangements are made for resear
grants, especially through existing bodies. Moreov
in view of what the Committee remarks about t
importance of associating more of the larger indu
trial firms with research and the development
research teams in this field, it might be well
associate industry with the development of any su
administrative arrangements. To do so could w
lead to suggestions for improved arrangements, a
the independent foundations may also have somethi
to contribute here, apart from what they are alrea
doing to encourage growing points in actual researc
Indeed, the Committee on Human Relations
Industry stresses the importance of seeking c
operation from the many institutions the intere
of which could be brought to bear on the developme
of social research in industry, and refers specifica
to the technical colleges, the industrial resear
associations and national bodies concerned wi
industry.

The Human Sciences Committee is stated to be king up proposals for research on a relatively large ale from certain well-established research groups hich between them cover the whole field from perimental psychology to sociology; but it seems ore than a little doubtful whether a body within e Department of Scientific and Industrial Research n have either the authority and status—or the sources—to ensure development of a co-ordinated ogramme of research, quite apart from the question hether this is the appropriate point from which ch an attempt should be made. This is not to ggest that the Department can make no contriution in its own right: on the utilization of results d questions of communication it has a growing lume of experience, including some current studies, hich should be of direct assistance, and research sociations should also be able to help in the selection problems, not simply those bearing on productivity t equally with regard to industry in its broad cial context and in relation to future developments. evertheless, even the Council for Scientific and dustrial Research seems likely to lack the standing at is required to put social research in industry on e basis that is now required.

The Joint Committee on Individual Efficiency in dustry has little to add about policy; but that ttle is in line with what is said by the Committee n Human Relations in Industry. It does not, deed, regret the initial emphasis on short-term search in its programme, as at the present stage of evelopment the success of such projects and the use f their results in industry are likely to provide fresh deas for basic research and open up new facilities for research workers in industry. It is, however, equally convinced of the need for balanced activity, and sees the need in the future to encourage the parallel growth of fundamental and applied research and the application of results. Moreover, it recognizes even more explicitly that action is required which goes beyond the particular responsibilities of the Medical Research Council and the Council for Scientific and Industrial Research, and it recommends in particular that certain problems of training and of the supply of trained scientific man-power—including the need to teach future engineers something of the difference between the characteristics of the human being and the machine—should be referred to the Lord President for comprehensive examination.

That particular proposal is open to Sir Hugh Beaver's recent criticisms; but it does indicate the need for a much wider examination of the situation and at a high level, at least by the Advisory Council on Scientific Policy, the observations of which on the report should be made without delay. This is even more urgent and fundamental than the survey of research needs which the Department of Scientific and Industrial Research is already undertaking. The Joint Committees have analysed the situation and needs with admirable lucidity and exemplary restraint, and their reports supply all that is needed to enable those concerned to ensure that research into the social and human problems of industry should be adequately supported and competently pursued, to press for the further examination at the appropriate level of the administrative problems of financial support and control, and the co-ordination of such research as well as the interpretation and communication of its results.

SCIENTIFIC APPARATUS IN THE ROYAL INSTITUTION*

By Sir LAWRENCE BRAGG, F.R.S.

THE stores of the Royal Institution contain many interesting examples of apparatus which has een used for research or lecture demonstrations, or hich has been given or bequeathed to the Instituon. The most valuable and historic pieces are on ermanent display in the ambulatory around the cture theatre. An overhaul of the collections has cently been undertaken, and in the course of this ork many treasures have been rediscovered and teresting facts about their history have come to ght. It is not easy to select from such a wealth of aterial. The examples to be mentioned may seem o have little connexion with each other. But, taken gether, they form a connected story, because they ll date from at least eighty years ago and they utline the state of knowledge at that time, the henomena in which the physicists were mainly terested, the kind of apparatus they used for emonstration, and the instrument makers' art of he period. The examples will be chosen from the ain branches of physics: mechanics, sound, light, lectrostatics, and electromagnetism.

The first example is a mechanical model for illustrating the combination and interference of waves (Fig. 1), and is a very elegant piece of instrumentation. It came to the Royal Institution in the De la Rue collection. Warren De la Rue was elected a member of the Royal Institution in 1851, and made a number of gifts during his lifetime. After his death, his widow presented his collection. The instrument shows five wave-forms simultaneously; the motions of the white beads on its upper part are always the sum of the

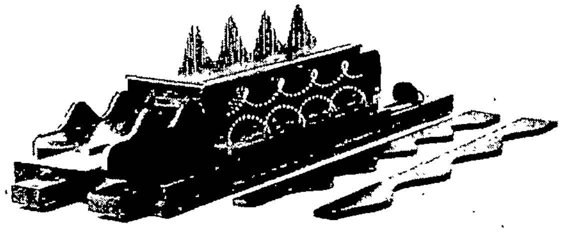

Fig. 1

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* Substance of a Friday Evening Discourse at the Royal Institution elivered on October 24.

two wave motions set on either side. The positions of the beads are determined by vertical and horizontal wave guides, and in an ingenious way the component waves can be given any phase and amplitude and various wave-lengths. It shows the combination of waves of different wave-lengths, interference of waves of the same wave-length, and plane, circular or elliptical polarization. It is said to have been designed by Wheatstone.

The next exhibit is one of the original Edison phonographs, shown by W. H. Preece before the Society of Telegraph Engineers on February 27, 1878. He said: "I may tell you that this instrument is only the second which Mr. Edison, the wonderful genius on the other side of the Atlantic, has ever made. It was brought over from America by my friend Mr. Puskas. . . . Some three weeks or a month ago I had the honour of lecturing before the Royal Institution and the phonograph then being a greater novelty than it is now, I had been promised by Mr. Edison an instrument for exhibition, but knowing that inventors cannot always fulfil their promises as to time . . ." (he took the precaution of having one made according to Edison's description). So although this early model arrived too late to be shown at the Royal Institution, it appears that it eventually found a home here; our specimen is identical in every way with that figured in Preece's paper. Tinfoil is pressed on to the surface of the cylinder with a grease adhesive. If one shouts "Mary had a little lamb" into the mouthpiece of the sound box while turning the handle, this classical poem is distinctly repeated when the needle on the sound box covers the same track again.

William Spottiswoode, who worked in the publishing firm of Eyre and Spottiswoode, became a member of the Royal Institution in 1864. He was a great amateur scientist, who equipped his own laboratory on a lavish scale. His collection of optical and electrical apparatus was presented by W. Hugh Spottiswoode in 1899, on the occasion of the centenary of the Institution. Spottiswoode gave a discourse in 1873 on "The Old and New Laboratories at the Royal Institution", and this, together with a description of his collection of apparatus, was reprinted as a pamphlet. It is a mine of information. One interesting sidelight is the following story which Spottiswoode told: "It is said that Mr. Fuller, the feebleness of whose constitution denied him at all other times and places the rest necessary for health, could always find repose and even quiet slumber amid the murmuring lectures of the Royal Institution, and that in gratitude for the peaceful hours thus snatched from an otherwise restless life . . ." he left a legacy to the Royal Institution for establishing the Fullerian professorship, which I now have the honour of holding. I hope some members of my audience to-night will be similarly moved. Spottiswoode's apparatus is distinguished for its costliness and rarity, as if he were determined to have the best and largest of everything. In particular, his Nicol prisms and tourmaline plates exhibited here are outstanding.

In 1879 W. E. Ayrton gave a discourse on "The Mirror of Japan and its Magic Quality". These mirrors are Chinese in origin, and called "mirrors that let the light pass through them". The back has a pattern in heavy relief. The front is brightly polished and appears to be quite uniform. If, however, the light from a bright point source is reflected on to a screen by the mirror, the pattern on the back is faithfully repeated in the patch of ligh The magic mirrors were known to antiquity (Ayrto says that they were described by Aulus Gellius i A.D. 100), though the origin of the magic propert was a mystery. So late as 1832 Sir David Brewst believed it was due to trickery, a slight etching scratching of the front surface having been made t correspond to the pattern on the back. The explan tion of the effect was first put forward by Govi in 186 as due to slight changes of curvature of the fac Ayrton, who had lived in Japan and had an oppo tunity of studying the manufacture of the mirror solved the mystery. The mirror is made slightl convex by scoring it in all directions with an iro rod before polishing, and the places where it is thic are less convex than those where it is thin, becau there is less yield to the strain created by the scorin process.

Electrostatic machines, and the electrostatic di charge in evacuated tubes, aroused the deepe interest. The Royal Institution has a long series electrostatic machines, from those of Nairne an Winter to a very large Wimshurst machine made b Wimshurst himself. The Spottiswoode collectio includes a large hammer-break induction coil whic gives a spark 17 in. long, and some hundreds discharge tubes which are beautiful examples glass-blowing. In these days of neon signs th phenomena of the discharge do not seem so strange t us as they did to former generations, but the excit tion of these tubes by the Spottiswoode coil is still very spectacular display.

An interesting 'gadget' from the United Stat depends upon the electrostatic discharge; it is a early form of gas lighter, presented to the Roy Institution in 1865. The advertisement (Fig. shows how it works. The turning of the ebonit knob and its sudden removal induces a charge o the cup, which discharges across the sparking point just above the jet and so lights the gas.

The next three examples show stages in th development of the dynamo. The Clarke machin (Fig. 3*a*) has coils on a yoke which rotates opposit the poles of a composite horseshoe permanent magne In the next stage, shown in Fig. 3*b*, Siemens designe an armature of a more modern form, and shape pole pieces, with a great improvement of the mag netic circuit, though permanent magnets were sti employed. It was then realized that an electr magnet would provide a more powerful field-magne

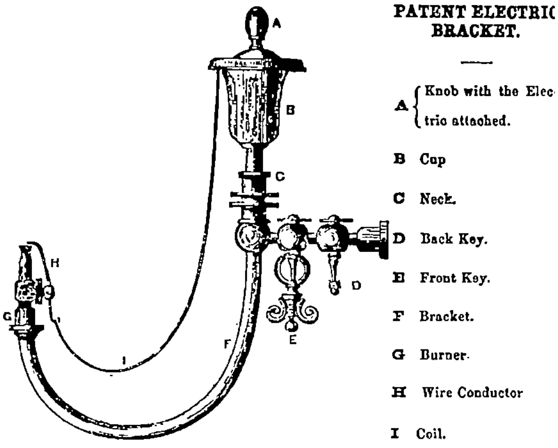
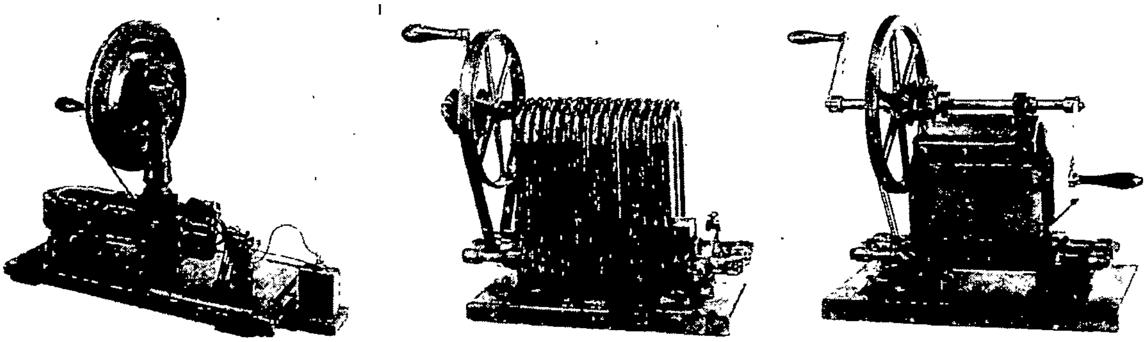


Fig. 2



(a) (b) (c)

Fig. 3

so a small dynamo with permanent magnets was mounted above the main dynamo and excited the field. In Ladd's machine, shown in Fig. 3c, the idea was taken one stage further ; the armature has two windings, one to excite the field and one to provide the current. Finally, of course, it was realized that part of the main current from the armature could be diverted to exciting the field.

We appear to have no record of how my last exhibit reached the Royal Institution. It is a very early example of the use of microfilm, which we are accustomed to think of as a quite recent development. These samples date back to the siege of Paris in 1870–71. Messages could be got out of Paris by balloon, and attempts were made to get them back by carrier pigeon, but the pigeons were poorly trained and harassed by hawks and falcons sent up by the Prussians, so few got through. In its extremity, the Government called in the help of M. Dagron, who devised a way of photographing the messages greatly reduced in size and stripping the pellicle of film from the plate. Each pellicle had 3,000 letters on it, and a pigeon could carry twenty pellicles in a quill attached to its tail, so it was possible to repeat the messages almost indefinitely until reply came from Paris that they had reached their destination. So successfully did the system work that the public were allowed to use it at 50 centimes a word—a very interesting example of necessity being the mother of invention.

When one surveys the apparatus in the storerooms of the Royal Institution and thinks of the many great occasions in the past when they were shown at the discourses, one cannot but realize that this place, of which we are the trustees and guardians, is a national treasure house of a unique kind.

EFFECTS OF ATOMIC RADIATION

In December 1955 the General Assembly of the United Nations set up a scientific committee for assembling, studying, and finally summarizing all available evidence on levels of ionizing radiation and radioactivity and their effects on man and his environment. The committee members were drawn from fifteen States : Argentina, Australia, Belgium, Brazil, Canada, Czechoslovakia, Egypt (United Arab Republic), France, India, Japan, Mexico, Sweden, U.S.S.R., United Kingdom, and United States. A summary report was drafted during the fourth session of the committee in February 1958 and approved at its fifth session in June. It is based on 213 reports from member States and specialized organizations, such as the World Health Organization. Much use has obviously been made of the two extensive reports published in 1956 by the United States and the United Kingdom[1].

The report of the United Nations Scientific Committee consists of two parts*. The first, shorter, one contains summarizing chapters on physical data, fundamental radiobiology, somatic and genetic effects of radiations, and conclusions drawn from the available evidence. The second part presents the data and considerations which form the material for the first. It consists of a number of 'annexes', some with additional appendixes, all with extensive literature references and numerous tables and graphs, but differing in the amount of space allotted to discussion and speculation. Undoubtedly the most valuable feature of the report is the assemblage of world-wide tabulated data on all aspects of radiobiology : including physical aspects such as the amount of cosmic radiation, of fall-out, and of radium content of the water in many regions of the Earth, and biological aspects such as the estimated doses for doubling mutation-rates in various organisms, or the amount of strontium-90 and cæsium-137 adsorbed into the human body in different countries and under different nutritional regimes.

A considerable amount of data which appeared after the publication of the American and British reports had to be assimilated. The quantitative estimates of fall-out had to take account of the two facts that (a) some fission products of nuclear explosions do not reach the stratosphere and are brought down by rainfall and sedimentation from the troposphere, and (b) fall-out from the stratosphere varies with latitude, regions between 30 and 50° N. receiving a considerably higher deposition than the world-wide average. The estimates of damage from ingested radioisotopes are affected by data on the strontium–calcium balance in different soils and foodstuffs and by the recognition of cæsium-137 as an important isotope which, unlike strontium-90, is distributed fairly evenly through the body, including the reproductive organs. Vegetable food, which reaches the human body without processing by animals, contains considerably larger amounts of strontium than animal food. A given amount of fall-out is therefore expected to result in higher concentrations of strontium-90 in the bones of rice-eating than of milk-consuming peoples. Diagnostic X-rays are still regarded as the major source of man-made radiation to the human body. The committee states that in medically highly advanced countries the average gonad dose from this source may equal that received from natural sources. The British Medical Research Council, which in its 1956 report estimated the lower limit of the gonad dose from diagnostic X-rays in the United Kingdom as 22 per cent of the background dose, has now revised this opinion[2]. In its detailed critical comment of the United Nations report, the British Medical Research Council accepts the statement quoted above, but points out that the world average must be much smaller. Certain types of examination, especially by fluoroscopy, give very high doses to the bone marrow. Less radiation is contributed by radiotherapy and very much less by occupational exposures.

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* Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. (General Assembly—Official Records : Thirteenth Session, Supplement No. 17 (A/3838).) Pp. iii+228. (New York : United Nations ; London : H.M. Stationery Office, 1958.) 2.50 dollars ; 18s. ; 10.50 Swiss francs.

In spite of these additions and alterations, the conclusions drawn from the data are essentially the same as those arrived at by the two national reports. After defining the 'genetically significant dose' as the average gonad dose to the individual weighted by the expected number of children, the Committee accepts "that radiation-induced mutations are, in general, harmful and increase in direct proportion to the genetically significant exposure, even at very low dose levels; and that a dose of between 10 and 100 rads (the rad is the unit of absorbed radiation: it is very close to 1 r.) per generation would probably be required to double the natural mutation rate in human populations". On the basis of calculations which the British Medical Research Council accepts only with certain reservations, the Committee estimates that about 4 per cent of all births are affected with hereditary disorders, and that a permanent doubling of the mutation-rate would increase this number to between 5 and 8 per cent. Estimation of the somatic damage is made difficult by ignorance of the precise dose-relationship between radiation and leukæmia, cancer, and other somatic effects, including ageing. Calculations have therefore been carried out separately for two alternative assumptions: the existence of a threshold below which the individual is not harmed by radiation, and a linear dose-effect curve like that found for mutations. These assumptions give different quantitative results, but in either case "it must be recognized that the exposure of human populations to increasing levels of ionizing radiations may cause considerable and widespread somatic damage". In regard to the possible shortening of the average life-span by radiation, the report is somewhat more reserved than the American one and restricts itself to the statement that such a shortening does occur in experimental animals, and that "it is possible that the same may be true for man". The Committee quotes recent British data indicating a correlation between, on one hand, leukæmia and other cancers in childhood and, on the other, irradiation of the fœtus, but points out that alternative interpretations cannot be excluded.

The practical recommendations are essentially the same as those in the two national reports. The introduction of individual radiation certificates is considered impracticable at present, but it is recommended that radiologists and dentists keep records of the quantities and qualities of radiation used not only in therapeutic but also in diagnostic procedure The Committee concludes that the cessation of nuclear weapon tests would "act to the benefit of human health", but considers a more definite proposal in this sense outside its terms of reference. Two minority proposals, one by the U.S.S.R., approved by Czechoslovakia and Egypt (United Arab Republic) the other by India, approved by Brazil, France, Japan and the United States, are less reserved in stressing the biological dangers of nuclear weapon tests and the desirability of the cessation of such tests.

So many workers are at present engaged in radio-biological studies that a report of this kind can never be completely up to date. Among those recent results which could not be included, two may be singled out because of their potential significance for estimates of radiation hazards. One is the finding by Griffen that males of a Bent-Tail strain of mice which had been given 700 r. of X-radiation produced a fair number of semi-sterile sons during their post-sterile period, presumably from irradiated spermatogonia. In one case, the semi-sterility was shown to be due to a translocation; for the remaining 25, cytologica tests have not yet been carried out, nor is it clear whether the semi-sterile condition was transmitted to half the sons, as would be expected if it were in every case due to a translocation. In Griffen's opinion these data invalidate the current belief that the production of translocations in spermatogonia can be neglected in calculations of genetical radiation damage; but since this belief is founded on clear data, both in *Drosophila* and the mouse (including new unpublished results by W. L. Russell), it would seem better to reserve judgment until a full analysis of this surprising observation is available. The second important result which appeared too late for inclusion in the report is the observation by W. L Russell and E. M. Kelly[4] that low-intensity gamma radiation (90 r. per week) produced fewer mutations in mouse spermatogonia than the same dose given in one intense exposure of X-rays.

Since this finding is likely to be used as an argument in the discussion of genetical radiation hazards, three points should be emphasized. First, even with low-intensity radiation, the per locus mutation-rate is still several times as high as that obtained by intense irradiation of *Drosophila* spermatogonia (Russell, personal communication). Secondly, the low-intensity test was carried out mainly because the dose-effect curve for high intensities had shown an unexpected depression at high doses, suggesting the disturbing possibility that the mutation-rate at very low doses or intensities might be *higher* than expected on a linear dose-effect relationship; this possibility could be ruled out by the low-intensity data. Thirdly, Russell cautions that, because of the nature of the material, it is at present difficult to predict what the dose curve will be like at still lower intensities of radiation. Thus, it is certainly not safe to conclude that the data support the concept of a threshold dose for genetic effects.

The three major reports on radiation hazards clearly are addressed to different sections of the reading public: the American report to the 'man in the street', the British to the general reader who is willing to spend time and effort on a thorough study of the whole question, the United Nations report to the expert. It is therefore doubtful whether the long and often highly speculative discussions of specialized biological phenomena (such as the biochemical activities of mitochondria and microsomes; the effects of radiation on kappa particles in *Paramecium* and on prophage in lysogenic bacteria; the possible existence of mutator genes in human populations; and many others) are necessary or, indeed, helpful to an appreciation of the presented facts. The expert in a particular field will know the original literature. Others (for example, a physicist reading the sections about bacterial genetics) will scarcely be able to take in this wealth of information and speculation, let alone use it for the intended purpose, namely, as basis for a critical evaluation of radiation hazards. Limitation of the space devoted to discussion would also have avoided much tedious repetition and overlapping between chapters. These, however, are minor defects which probably will correct themselves through the reader skipping whatever does not interest him by being either too familiar or too unfamiliar. They do not detract from the high value of this impressive presentation of carefully collected and critically evaluated data and the considered judgments and recommendations based on them.

C. AUERBACH

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[1] Auerbach, C., *Nature*, **178**, 453 (1956).

[2] Medical Research Council (H.M. Stationery Office, 1958).

[3] Griffen, A. B., *Proc. U.S. Nat. Acad. Sci.*, **44**, 691 (1958).

[4] Russell, W. L., and Kelly, E. M., *Science*, **127**, 1062 (1958).

IODINE-131 IN HUMAN THYROIDS FOLLOWING THE WINDSCALE REACTOR ACCIDENT

By G. MAYCOCK and J. VENNART

Radiological Protection Service, Belmont, Sutton, Surrey

DURING the latter half of October 1957, following the Windscale reactor accident, we observed that the gamma-ray activity of certain members of the staff of the Radiological Protection Service, at Belmont, Surrey, was higher than expected from previous estimates of their body content of the naturally occurring isotope of potassium, potassium-40 and the fission product cæsium-137. The source of the greater part of this increased activity was identified as iodine-131, which had not occurred previously in the gamma-ray spectrum of these individuals, and there was also evidence of a slight increase in the cæsium-137 content. However, since iodine is concentrated in the thyroid gland, whereas cæsium is distributed throughout the body, it was evident that, so far as radiation damage to the individual might be concerned, only the increased amount of iodine-131 would be important. We decided, therefore, to make some measurements of the iodine-131 in human thyroids. In view of the account of the Windscale reactor accident[1] and the recent paper by Stewart and Crooks[2] reporting the subsequent contamination by nuclear debris of many parts of England, we are reporting our measurements as a matter of interest, since few organizations will possess the equipment and the low-background laboratory which is essential for the measurement of the low levels of thyroid activity reported here.

The measurements were made in a low-background laboratory using a sodium iodide (thallium) crystal, 2 in. × 1·75 in. in diameter, optically coupled to a photomultiplier tube, the output of which was fed via amplifiers to a 100-channel pulse-height analyser. For the measurement of an individual, this crystal was arranged over the thyroid with the curved surface touching the skin. The equipment was calibrated with a known amount of iodine-131 in two polyethylene bottles having dimensions very close to that of the lobes of an average thyroid. The bottles were strapped, 6 cm. apart, on to the neck of a model of the human body containing distilled water so that the centres of the model lobes were 3 cm. below the proximal crystal surface. This particular dimension was used, since measurements by one of us (J. V.) on more than a hundred persons submitted for diagnosis of thyroid function using iodine-131 had shown that the mean effective depth of the thyroid below the anterior skin surface was approximately 3 cm. The space between the model lobes and the crystal was packed with polyethylene to give an approximation to the actual case of a human neck. Although a larger distance between the crystal and the neck would have minimized errors due to variations in depth of thyroid below the surface of the skin, the method used gave reasonable accuracy and it had the merit, with regard to the low levels expected, of giving maximum sensitivity.

The iodine-131 in the thyroid of an individual was then assessed by comparing the counting-rate within the 0·36-MeV. photo peak of his gamma-ray spectrum with the corresponding counting-rate in the spectrum of the model. An appropriate correction, which was very small, was made for the contribution from potassium-40 and cæsium-137 within the individual's body. Each individual was measured for a period of 15 min.; the standard deviation due to counting-background amounted to 0·04 mμc. iodine-131. An idea of the reliability of these measurements may be obtained by comparing our measurements on one individual, person *K* in Table 1, who was a visitor from Leeds, with that made by Burch and Spiers[3] at Leeds. They found that this individual had 8·2 mμc. of iodine-131 in his thyroid on October 31 and 8·8 mμc. on November 2. These values are in excellent agreement with our own measurement, which was 8·5 mμc. on November 1.

Eighteen persons were measured, the majority of whom were resident either in, or on the fringe of, the Greater London area. The exceptions were persons *B* and *L*, who were resident in mid-Surrey but working in Belmont, and person *K*, who was a visitor from Leeds. Apart from *F* and *G* (two children aged 12 and 10½ years, respectively) the group comprised both male and female adults.

It was not convenient to make more than one measurement in the case of most of these individuals, but where series of measurements were possible they are listed in Table 1.

Table 1. Iodine-131 Content of Thyroid (in mμc.)

Subject	Date of measurement Oct. 1957 31	November 1957 1	4	5	8	15	22	Jan. 1958 2
A	2·6							
B	0·6							
C	1·8			1·5	1·0	0·7		
D	2·0					0·8		
E	2·1					0·2		
F	1·8							
G	1·3							
H		6·3		5·1	3·8	2·6	1·8	0·09
I		2·4			1·5			0·16
J		0·9						
K		8·5						
L		1·0						
M		1·2						
N		1·6	1·0					
O		1·4				0·3		
P			1·2					
Q				1·5	1·4	1·0		
R				0·6				

The results for the one person, *H*, on whom we were able to make a series of reliable measurements showed an elimination-rate from the thyroid which was slower than the radioactive decay-rate of iodine-131. This clearly indicates that the uptake of iodine-131 into the gland was continuing throughout the period of measurement. Since the atmospheric contamination of iodine-131 at the time of measurement was negligible[2], the only route of entry into human thyroids would be by ingestion, such as would result from the daily intake of milk obtained from cows grazing contaminated pastures. The fact that person *H*, who showed the highest value of iodine-131 in the thyroid for the London group, had by far the highest milk intake (at least two pints daily) also supports the view that the main source of iodine-131 was in milk. This is in agreement with the views expressed in the report of the accident[1]. Furthermore, we were able to detect iodine-131 in London milk during the period indicated in Table 1; but the activities were too low to state the amount with confidence.

All the persons listed in Table 1, apart from *K*, would have been drinking milk from a large London dairy during working hours, and all except *B* and *L* from one or other of the large London dairies while at home. The milk supply for the dairies comes from a wide area of the country around London.

In order to calculate the dose of radiation received by the thyroid, it is first necessary to know how the thyroid-level of iodine-131 varies with time after the event. Since the main route of entry to the human thyroid was via milk, then as the cloud with its iodine-131 from Windscale passed over Britain on October 11, we may expect that the first day on which milk contained this isotope was October 12. This is in agreement with the findings at Windscale reported by the committee of inquiry[1]. In the early days following the accident there might have been a period during which the activity in milk increased, since some delay would occur while the iodine-131 on the grass passes through the cow. When the level of iodine-131 in milk is in equilibrium with that on herbage, the activity in milk will decrease at a rate determined by radioactive decay and by other processes, for example, leaching by rain and decay of the vegetation. With regard to an estimation of the radiation-dose to the thyroid of a human drinking this milk, it is also necessary to consider losses of iodine-131 from the thyroid due to biological elimination and to radioactive decay. It is obvious, therefore, that the pattern of thyroid uptake and excretion may be very complex, especially during the early days after the accident. Our results relate to a period which begins several days after the accident, when we might expect the iodine-131 in milk had reached equilibrium with that on the grass. These results will therefore give no information about the pattern of the initial build-up in the thyroid. However, since our intention is to make an estimate only of the dose in the thyroid, the following simplification of the problem is permissible.

If we assume that the activity in milk decreases exponentially with time, and with the same decay constant, λ day^{-1}, as that for iodine-131 in the thyroid, then the amount of iodine-131 in the thyroid, *q* mμc., at any time, *t* days, after the initial ingestion, is given by the equation:

$$\frac{dq}{dt} = B \exp(-\lambda t) - \lambda q \qquad (1)$$

where *B* is the initial daily intake in mμc./day. Hence,

$$q \text{ (in m}\mu\text{c.)} = Bt. \exp(-\lambda t) \qquad (2)$$

The above assumption will be valid, and this equation will describe the pattern of uptake, and excretion, of iodine-131 from the thyroid if, for example, decrease of activity in milk and in the thyroid is principally by radioactive decay. Since the rate of biological elimination of iodine-131 from normal human thyroids is small[4], the effective decay constant in the thyroid will be only slightly greater than the radioactive decay constant of iodine-131, which is 0·087 day^{-1}. It is, perhaps, not surprising, therefore, that the results for person *H*, on whom the greatest number of measurements were made, can be fitted very closely (see Fig. 1) to equation 2 when $\lambda = 0{\cdot}1$ day^{-1}, $B = 2{\cdot}3$ mμc./day and *t*, in days, is measured from zero time, October 12.

By integrating the expression $Bt(\exp - \lambda t)$ over infinite time, it can be shown that the total thyroid dose of iodine-131 amounted to 230 mμc. days. Using values given in the Recommendations of the International Commission on Radiological Protection[4] for the effective energy per disintegration, 0·22 MeV., and the weight of the thyroid, 20 gm., it follows that the total mean radiation dose to the thyroid of person *H* due to the accident amounts to 0·13 rad.

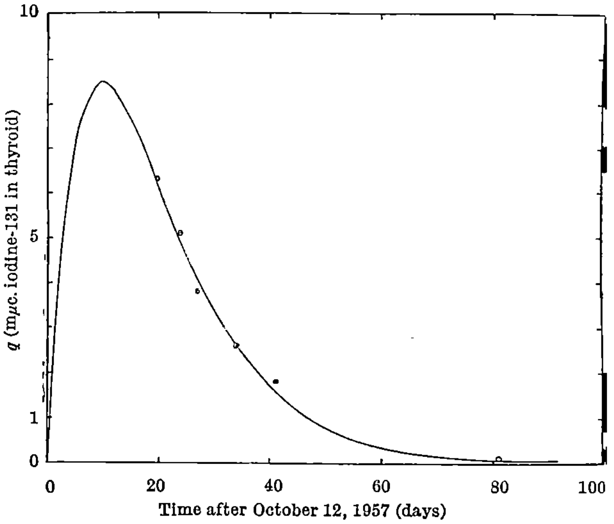

Fig. 1. Uptake and excretion of iodine-131 in human thyroid following the accident at Windscale. The curve represents the equation $q = 2{\cdot}3t \exp(-0{\cdot}1t)$; ●, experimental determinations on subject *H*

If we assume the same pattern of uptake throughout the group, then it is evident from the results in Table 1 that the average person in the Surrey and London groups received about one-third of this value, or 0·04 rad. The error, due to neglecting the possibility of initial 'build-up of activity in milk, should be small. An estimate of the upper limit of thyroid dose may be made by assuming—quite unrealistically with regard to the fact that milk contained iodine-131 at the time of the measurements—that this accident was due to a single intake of iodine-131 on October 11, when the main cloud passed over London. Then assuming that the half-period for decay thereafter was that expected for normal people[4], 7·5 days, since the mean level of iodine-131 in the London and Surrey group was about 2 mμc. on October 31, it may be shown that the total mean dose to the thyroid was 0·08 rad, or about twice that estimated by the more likely conditions above. The two children, *F* and *G*, had the same milk supply and were drinking about the same quantity of milk daily as person *N*. The similarity of the results for these three individuals suggests that there is little difference in the uptake of iodine-131 into the thyroid at different ages. Therefore, because of the different thyroid weights, the dose to the children's thyroids was twice that to the adult's.

The magnitude of the radiation dose to adult human thyroids in the London and Surrey people measured was therefore comparable with that expected each year from natural background radiation which, for example, amounts to about 0·1 rad per annum in Leeds[5] and about 80 per cent of this value in Sutton[6].

[1] Accident at Windscale No. 1 Pile on 10th October, 1957. Cmnd. 302. (H.M.S.O., 1958).

[2] Stewart, N. G., and Crooks, R. N., *Nature*, **182**, 627 (1958).

[3] Burch, P. R. J., and Spiers, F. W., University of Leeds (private communication).

[4] Recommendations of the International Commission on Radiological Protection, *Brit. J. Radiol.*, Supp. No. 6 (1955).

[5] Spiers, F. W., and Griffith, H. D., *Brit. J. Radiol.*, **29**, 175 (1956).

[6] Vennart, J., *Brit. J. Radiol.*, **30**, 55 (1957).

PROGRESS OF CANCER RESEARCH

THE current annual report of the British Empire Cancer Campaign for 1957* consists of a volume of more than 500 pages plus a supplement of 156 pages.

During the year the Campaign financed cancer research by grants of more than £600,000 ; the index of research workers mentioned contains nearly 1,100 names. Some idea of the type of research described in the report can be gained from Table 1, which divides up the different studies into a number of manageable groups. Any such classification is certainly liable to over-emphasize some lines of work and under-estimate the importance of others, but there seems no other way of indicating, however approximately, their relative attraction for those engaged in cancer research.

This table presents a puzzling aspect of cancer research, for why is it that the most interesting topic to-day, namely, smoking and lung cancer, is at the bottom of the list and not at the top ?

The report has the virtue of enabling the specialist to keep *au courant*, year by year, with what other workers in his field are doing ; but for other kinds of reader the report will prove heavy going, for it resembles, more and more, a catalogue of highly technical abstracts on abstruse subjects. This difficulty of reporting cancer research has developed partly because financial and other facilities have increased very rapidly, the result being to encourage expansion, not directly on cancer but on subjects which are somewhat indirectly related to it and are more amenable to investigation.

A further function of a report such as this is the necessary one of showing that the many and various recipients of Campaign grants have used those grants to good advantage. To do this, it is arranged geographically, according to the place where the work is done, and not by subject. But it must be recognized that the scientific value of the volume is much diminished by this. How much more striking a survey of progress in cancer research this could be made if work in each field was gathered together in even the roughest of logical orders. If that is impossible, is it too much to ask again for a subject index ?

Table 1. THE RELATIVE NUMBER, VERY APPROXIMATELY, OF INVESTIGATIONS DESCRIBED IN THE ANNUAL REPORT OF THE BRITISH EMPIRE CANCER CAMPAIGN FOR 1957

Radiation therapy ; radiobiology, radioisotopes	38
Carcinogens ; carcinogenesis	29
Nucleoproteins	27
Biochemistry of tumours ; cytochemistry and cytology	20
Hormones ; steroids	19
Clinico-pathology	20
Chemotherapy	12
Viruses ; fowl tumours	10
Immunology	8
Mutagens ; genetics	8
Tissue culture	6
Demography ; statistics	5
Smoking and lung cancer	5

The supplement (156 pages) to the report is by the veteran epidemiologist-statistician, Dr. Percy Stocks ; it is an account of his monumental study, "Cancer Incidence in North Wales and Liverpool Region in Relation to Habits and Environment", and is composed of sections on local differences in death-rates ; morbidity-rates ; urban and rural residence ; Welsh and Irish parentage ; marital history ; dietary histories ; smoking and smoke ; soil ; other factors (use of oil lamps ; use of petrol lighters ; streptococcal infections ; vaccination against smallpox ; residence in house with vegetable garden) ; national and vital statistics.

An interesting line of approach to the problem of chemical carcinogenesis is the persistent effort by the Birmingham group under Orr to prove that the primary lesion in carcinogen-induced skin carcinoma in the mouse is in the dermis, not the epidermis. The great majority of serious attempts to explain cancer begin by assuming that the essential change occurs in the cells which are proliferating and invading—in the malignant cells themselves. Indeed, the phenomena of metastasis and transplantation, where malignant cells clearly establish themselves of their own initiative in normal tissues, can scarcely be explained otherwise. Yet there have been many who have suggested that the changes seen in the stroma around early carcinomata (they are often conspicuous, especially in skin tumours) are more important than those in the epithelium. There has been little except equivocal histological evidence for this view in the past, but the experiments of the Birmingham group put it on a firmer basis. Their principal earlier experiments were simply of this type: mouse skin was painted with methylcholanthrene in carcinogenic doses, and then, before tumours developed, grafts were exchanged between painted and non-painted areas. If the grafts were made of pure epithelium by the Billingham–Medawar trypsinization technique, more tumours appeared in areas where normal epidermis had been grafted to a painted site than where painted epidermis was grafted to a normal site. Though there are several possible sources of error in these experiments, *a priori* they indicated the possibility that stromal changes in the graft-bed were important. The newer experiments have similar implications. Pure epidermal grafts implanted subcutaneously with crystals of methylcholanthrene do not, they report, give rise to tumours. On the other hand, if pellets of methylcholanthrene are implanted subcutaneously into mice, removed after as little as two weeks, and replaced by a small Thiersch graft of skin, squamous carcinomata appear. Yet the amount of hydrocarbon remaining at the site of the pellet after its removal is far below a normal carcinogenic dose. The evidence that in these experiments some stromal change is a major factor in carcinogenesis would seem on the face of it to be hard to deny. However, ovarian transplantation experiments reported in another connexion from the same school, but involving the same principle, gave results less uncomfortably at variance with accepted theories.

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* British Empire Cancer Campaign. Thirty-fifth Annual Report covering the year 1957. Part 1 : The Chairman's Statement and the Accounts. Pp. xl. Part 2 : The Scientific Report. Pp. xli+528. Supplement to Part 2 : Report by Percy Stocks on Cancer Incidence in North Wales and Liverpool Region in Relation to Habits and Environment. Pp. iv+156. (London : British Empire Cancer Campaign, 1958.)

It is noteworthy that none of the Campaign laboratories engaged in the cigarette–bronchial cancer problem has yet succeeded in producing tumours experimentally with any substances derived from tobacco; yet the statistical evidence for the association is further increased by several contributions.

The report of progress made at the Westminster Hospital towards a possible treatment of leukæmia by irradiation and marrow replacement is disappointingly brief. Three cases have had irradiation to ilea and upper femora, sufficient to suppress their marrow content, followed by grafts of normal marrow from donors injected into the lower abdominal aorta; steroids and nitrogen mustard were also given. It is reported that evidence of successful establishment of the homograft marrow was obtained in two cases.

Much work is in progress on the fashionable homotransplant-immunity theory of cancer; but judgment must be suspended on most of it for the present. One of the most interesting (though perhaps the one least directly related to cancer) is an admirable brief account of Billingham's work on the 'runt' disease of mice. It will be remembered that new-born mice injected with spleen cells of a donor strain become tolerant to grafts from the donor strain in later life, but that, with many strain combinations, the recipient mice fail to grow and show severe atrophy of all lymphoid tissues; this is thought to be due to an immune reaction by the donated graft cells against the host. In general, further experiments support this interpretation, but some discrepant findings have emerged. Buffy coat suspensions, which cannot be used for the passive transfer of homotransplant immunity, will produce runt disease. Bone marrow under some conditions can produce tolerance without runt disease, and experiments with F_1 hybrids have not altogether confirmed the results predicted.

The reports from physicists working on various forms of cancer research show that these workers fall into two main classes. In one group are those who concentrate on the physical aspects of biological problems and who are really becoming a race of biophysicists, and in the other are those who concentrate on improvements in the equipment and techniques used in this very wide field. These two main classes meet in the common field of radiation protection. The sensitive measuring techniques developed for this very essential service are now being put to investigating the various sources of natural radioactivity and its role in the possible production of malignant conditions.

One centre working on this problem has measured the natural radioactivity occurring in forty types of soils and fertilizers as well as hundreds of other environmental materials. A chalk pit has been excavated to form a low-activity counting area in which various substances including unprocessed milk have been assayed for isotopes such as cæsium-137 and iodine-131 which may be present. Theoretical studies have been made of the dosimetry of possible depositions of a beta-emitting isotope in bone. These calculations have been applied to the comparative dosage of radium and of strontium-90 when these elements are present under similar conditions. Total body counters are also being improved upon each year and a portable high-pressure ionization chamber has been developed which enables normal background dose-rates to be measured to an accuracy of ± 2 per cent in a measurement time of about 3 min. Studies of the 'rain-out' from tests of nuclear weapons exploded at Maralinga have been continued. Clear evidence of the presence of artificial radioactivity in rain 18 hr. after the explosions has been obtained. More definite information has been collected from measurements on rain which fell up to 14 days later.

Radioactive isotopes are now being widely used as a routine research tool, and many refinements of existing counting techniques are reported. Most of these modifications are designed to increase the sensitivity so as to enable lower levels of radioactivity to be used for *in vivo* studies. At the opposite end of the scale, large amounts of radioactive isotopes such as cobalt-60 and cæsium-137 are being used for the treatment of malignant diseases, and measurements have been made of the dosage distribution from a source of 1,150 c. of cobalt-60.

Reading this report as a whole leaves one with the impression that research in the field of cancer, as in most other fields, is becoming steadily more of a team project in which each member of the team needs to know a little of all the other aspects as well as a lot about his own. Physicists working on biological problems need to have a wide knowledge of biology, and biologists using physical techniques and methods nowadays require a grounding in physics to enable them to get the best interpretation of the data obtained using present-day equipment and to suggest possible modifications of such equipment for their particular problems.

OBITUARIES

Dr. Felix Oswald

Dr. Felix Oswald, a distinguished geologist and archæologist, died on November 3 on the ninety-second anniversary of his birth in 1866.

After gaining the degree of B.A.(London), Oswald entered the Civil Service. In his spare time, however, he made a study of geology, botany and zoology, and eventually presented these as his subjects for the B.Sc. degree examination, London, in which he gained first-class honours.

In 1898 he accompanied N. B. Lynch as geologist on a tour through Turkish Armenia. On their arrival at Lake Van, he made a careful investigation of the rocks and structure of the Crater of Nimrud, a volcano on the west shore of the lake. He later wrote "The Geology of Armenia" and presented it as his thesis for the degree of D.Sc.(London). As the cost of providing the requisite number of copies for the examiners proved prohibitive, he set up a press and printed 200 copies himself. The book had 600 pages and a number of coloured illustrations. He also made a geological map of Armenia and a coloured relief model of the Crater on the scale of 1 in. to the mile.

In 1907 he was elected a Fellow of the Geological Society of London. He also received from the Council of the Society an award from the Murchison Fund in recognition of his work in Armenia. In 1911 he went to Central Africa, on behalf of the British Museum, to investigate fossiliferous beds of Mid-Tertiary Age that had been discovered north-east of Victoria Nyanza. Four years later he was sent to the Caucasus in response to a request from the Russian Government for a geologist to search that region for additional sources of oil. In this work he was successful, and in addition produced a geological map of the Caucasus mountains.

Meanwhile, Oswald was appointed probate registrar for the East Midlands and accordingly moved to Nottingham. Here he became interested in Margidunum, a Roman station situated on the Fosseway. About 1911 he started excavating the site and continued until his retirement, in 1936, to Solva in Pembrokeshire. He built up a remarkable collection of pottery from the site. This is now housed in the museum of the University of Nottingham. He visited every important collection of Roman pottery in Europe. With the unrivalled knowledge thus gained, he produced several magnificent works on terra siggillata and many small ones, including detailed accounts of Margidunum. He won an international reputation, and even during his long retirement was visited and consulted by scholars from many parts of the world.

H. H. Swinnerton

Dr. Francisco Duran-Reynals

The death of Dr. F. Duran-Reynals, which occurred on March 27, 1958, deprived experimental pathology of one of its outstanding figures. Apart from many well-known studies of the role of viruses in the etiology of cancer, I particularly wish to record Duran-Reynals's influence—not so widely appreciated—in stimulating this field over many years less directly, and in encouraging developments which in turn have facilitated recent dramatic advances, particularly in the United States, in our knowledge of tumour viruses.

Francisco Duran-Reynals was born in Barcelona on December 5, 1899. After graduating from the University of Barcelona as M.D. in 1925, he then spent three years in work at the Pasteur Institute in Paris (with Profs. A. Besredka and E. Wollman), and (with Dr. J. B. Murphy) at the Rockefeller Institute, New York, to the staff of which he was appointed in 1928. In 1938, he became research professor at Yale University School of Medicine, with support from the Jane Coffin Childs Memorial Fund for Medical Research.

Duran-Reynals's earlier work was mainly concerned with the so-called ground-substance of the mesenchyme, and arose from the discovery of spreading factors—hyaluronidase and others—in mammalian testes (1928), bacteria (1933), snake venom (1936), and many other sources. His studies of viruses in relation to cancer date from 1938, and were continued to the end of his life, with much assistance from his wife, M. L. Duran-Reynals. These studies bore specially upon such aspects as virus variation and adaptation, antigenicity and epidemiology, and an important observation (of particular interest in relation to more recent discoveries) was of their maximal infecting power when injected into immature hosts.

Duran-Reynals was the recipient of many honours, notably (in 1952) the Anna Fuller Memorial Prize for Medical Research. His contributions not only to the above problems but also to many others in experimental pathology are embodied in upwards of a hundred papers, the last (1958) being a study of the infectious pulmonary adenoma complex in sheep.

In all he did he was not only scientist but artist as well. None who had the privilege to know him will soon forget his endearing qualities, his courage and gaiety, or his love of his native Spain.

A. Haddow

Dr. R. C. Fisher

Dr. Ronald Campbell Fisher was born on August 6, 1899, at Edinburgh, and died unexpectedly in his sleep on October 23. He was the elder son of Archibald W. Fisher, solicitor, and Catherine Dick Fleming. From George Heriot's School he proceeded to the University of Edinburgh, where he graduated in forestry in 1921 and was awarded the medals for advanced forestry and forest zoology. Following studies at Kew and Rothamsted on a research scholarship awarded by the Ministry of Agriculture and Fisheries, he received his doctorate for a thesis on forest insects in 1923.

After working for two years at the Imperial Forestry Institute, Oxford, Fisher transferred to the Forest Products Research Laboratory (Department of Scientific and Industrial Research) at Princes Risborough, as the first officer-in-charge of the Entomology Section. At that time, little was known of timber-boring insects in Great Britain, but during the thirty-one years he was in charge of this work, he published, or was the co-author of, more than sixty papers and H.M. Stationery Office publications on this group of insects, and his staff published many more. His main contribution to the literature was the four papers which he published in the *Annals of Applied Biology* under the title of "Studies in the Biology of the Death Watch Beetle". These papers, and those of the late W. G. Campbell (officer-in-charge, Wood Chemistry Section, Forest Products Research Laboratory) on the nutritional aspects of this species, formed a basis for improved control measures in the light of the knowledge revealed on the association between death watch beetle attack and preceding fungal decay. For his paper on "Recent Work on Wood-Destroying Insects" he received a silver medal from the Royal Society of Arts. He read his last paper, entitled "Developments in the Control of Timber Insects", before the Society of Chemical Industry only three days before his death.

During his years at the Forest Products Research Laboratory, Fisher was constantly consulted on problems concerning wood-boring insect infestations, not only in timber, joinery and furniture, including many of the ancient buildings of historical interest in Britain, but also on infestations of tropical timbers. A physical disability had prevented him from following the career of a forest officer, but he retained a keen interest in the entomological problems of forest insects and in particular of the *Ambrosia* beetles. The post-war shortage of traditional timbers and demand for substitutes from among tropical species brought the *Ambrosia* beetle problem to the fore, and it was mainly due to his efforts that the West African Timber Borer Research Unit was set up by the Colonial Office in 1952. The supervision of the training of the staff of this unit and their research programme became one of his chief interests. He also served on H.M.S. *Victory* Technical Advisory Committee and on the committee set up by the Central Council for the Care of Churches. He was elected a Fellow of the Royal Society of Edinburgh in 1952.

He leaves a wife and two sons of whom the elder, Dr. R. Campbell Fisher, is studying insect parasites at the Entomological Laboratory, Belleville, Ontario, Canada, and the younger, aeronautical engineering at the University of Bristol. J. D. BLETCHLY

NEWS and VIEWS

Atoms for Peace Award:
Prof. G. C. de Hevesy, For.Mem.R.S.

THE second Atoms for Peace Award of 75,000 dollars and a gold medallion, founded as a memorial to Henry and Edsel Ford, has been made to Prof. G. C. de Hevesy, associate of the Institute for Research in Organic Chemistry, University of Stockholm, and of the Institute of Theoretical Physics, Copenhagen. In announcing the award, Dr. Detlev Bronk, president of the Rockefeller Institute for Medical Research and of the U.S. National Academy of Sciences, said that Prof. Hevesy was selected unanimously from 111 nominations for "his basic contribution to the peaceful uses of atomic energy in the discovery and development of tracer techniques in chemistry, biology, and medicine, using natural and artificial radioactive and stable isotopes for his continuing work in these fields". Prof. Hevesy is a Foreign Member of the Royal Society and was awarded the Copley Medal in 1949. He received the Nobel Prize for Chemistry in 1943.

United States Atomic Energy Commission:
Dr. Frank K. Pittman

DR. FRANK K. PITTMAN has been appointed director of the Division of Reactor Development of the U.S. Atomic Energy Commission, and the functions previously assigned to the Office of Industrial Development have been transferred to that Division, except for those having to do with isotope development. The functions of isotope development will be undertaken by an Office of Isotope and Radiation Development with Dr. Paul C. Aebersold acting in charge.

Dr. Pittman graduated at Vanderbilt University and received his Ph.D. in inorganic chemistry from the Massachusetts Institute of Technology. He has been associated with the United States atomic energy programme since 1944, when he joined the staff of the Los Alamos Scientific Laboratory. He was in charge of plutonium production at the Laboratory until 1948. He has been director of the Office of Industrial Development since it was established in December 1957, and also had been serving as acting director of the Division of Reactor Development since August 5, following the resignation of W. Kenneth Davis.

Smith Kline and French Research Institute:
Prof. W. A. Bain

PROF. W. A. BAIN, who has held the chair of pharmacology at the University of Leeds since 1946, has accepted an invitation to become director of the Smith Kline and French Research Institute, and will resign his university appointment to take up this new post. After graduating in Edinburgh, William Alexander Bain became assistant to the late Sir E. Sharpey Schafer in 1928. In 1931, he was appointed lecturer in experimental physiology in the University of Edinburgh, before moving to Leeds in 1934, where he became, first, lecturer in physiology and later reader in pharmacology. Prof. Bain has conducted research on the autonomic nerves, on adrenaline and on the antagonists of histamine.

Laboratories for the Smith Kline and French Research Institute are under construction at Welwyn Garden City and are expected to be completed by the late summer of 1959. The research team which Prof. Bain will direct will form an important part of, and be complementary to, the extensive research effort of the parent company in Philadelphia. The Company believes that by having research teams both in Great Britain and in the United States there will be advantages to both by the interplay and exchange of scientific fact, opinions, outlook and approach.

Bell Telephone Laboratories: New Directors of Research

DR. W. D. Lewis, of Mendham, and Mr. A. H. White, of Summit, have been appointed directors of research at Bell Telephone Laboratories, Murray Hill, New Jersey. Dr. Lewis will be in charge of research on switching and transmission systems and techniques. Mr. White will be director of research in the physical sciences, including physics, chemistry, semiconductors, solid state electronics, metallurgy and materials. With Dr. J. R. Pierce, formerly director of research in electrical communications and now director of research in communications principles, Dr. Lewis and Mr. White will report to Dr. W. O. Baker, vice-president in charge of research.

Commonwealth Co-operation in Scientific Research

In the course of a speech on October 20 when opening the Esso Research Laboratories at Abingdon, the Lord President of the Council, Viscount Hailsham, referred to our comparative neglect of research as a nation, to which we devoted far too little of our resources, and emphasized the role of industry and the universities as well as of the Government. He said that in the view of the Government it was most important that there should be available in the Commonwealth, for those members who needed it, advice and assistance from other members including the United Kingdom, wherever these were available and funds could be found to meet it. Accordingly, the Government had announced at Montreal that, under the general control of the Committee of the Privy Council, an Overseas Research Council would be set up concerned with scientific research overseas, particularly in the Commonwealth (*Nature* of November 22, p. 1413). Our existing organizations in industrial, medical, and agricultural science would be available to give assistance through this new body, and he hoped new and fruitful scientific links would be formed in this way between Great Britain and members of the Commonwealth. Secondly, Lord Hailsham welcomed the attention which the United States was giving to research in the tropics, and particularly in Africa, as a fruitful field for Anglo-American co-operation (*Nature* of November 8, p. 1276).

The Institute for Strategic Studies, Ltd.

The formation of the Institute for Strategic Studies, Ltd., for the study of defence and disarmament has been announced. The Institute will be international, but the headquarters will be in London. Mr. Alastair Buchan, formerly defence and diplomatic correspondent and now assistant manager of the *Observer*, has been appointed director. The purpose of the Institute is to provide a focus for the study and discussion of the effects of political and scientific developments upon strategy, Western defence policies, and disarmament plans. It is also intended to develop a reference centre. The Ford Foundation in New York has made a grant of 150,000 dollars to finance the Institute for the first three years.

The founder members of the council of the Institute are: Sir Kenneth Grubb (chairman, Commission of the Churches on International Affairs) (*chairman*), Mr. Richard Goold-Adams (*vice-chairman*), Lord Salter (*honorary treasurer*), Prof. P. M. S. Blackett (professor of physics, Imperial College of Science and Technology), the Rev. Alan Booth (secretary, Commission of the Churches on International Affairs), Rear-Admiral Sir Anthony Buzzard (director, Vickers-Armstrongs, Ltd.), Air Chief Marshal Sir Ronald Ivelaw-Chapman, Lieutenant-General Sir John Eldridge, Mr. Kurt Hahn (former headmaster, Gordonstoun and Salem Schools), Captain B. H. Liddell Hart, Sir William Hayter (warden of New College, Oxford), Mr. Denis Healey, M.P., Mr. Michael Howard (lecturer in war studies, King's College, London), Sir James Hutchison, M.P., Lord McNair, Marshal of the R.A.F. Sir John Slessor. Sir Henry Tizard, Mr. Donald Tyerman (editor of the *Economist*), Canon H. M. Waddams (secretary, Church of England Council on Foreign Relations), Lord Weeks, and Mr. C. M. Woodhouse (director-general, Royal Institute of International Affairs). The Institute will also have an international advisory committee on strategy, defence, and international affairs throughout the Free World.

Committee of Public Accounts: Report for 1957–58

In its third report for the session 1957–58 (pp. 32. London: H.M. Stationery Office, 1958. 1*s*. 6*d*. net) the Committee of Public Accounts admits that the evidence given to the Committee last session regarding the cost of construction of the Jodrell Bank radio telescope was gravely inaccurate and misleading. The accounting officer now states that he is satisfied, after discussing the matter with the University of Manchester, that there was extensive consultation between the consultant engineers and the professor in charge on questions of design. There was, in fact, the fullest collaboration on scientific and technical matters between the consultants and the professor, and accordingly the concern expressed by the Committee in its third report for the session 1956–57 is essentially unfounded. It is, however, still not satisfied with the financial control exercised over this scheme, either by the Department or by the University, and welcomes the Treasury minute on its previous report indicating that steps are being taken to ensure close control by both the university and the Government department concerned in any future case of this kind. The Treasury has now authorized payment of an additional grant of £130,000, making a total of £560,000, and the Committee welcomes the assurance that the balance of the expenditure for the construction of the telescope will be found from other sources by the University (*Nature*, November 29, p. 1484).

United States Euratom Agreement

An agreement for co-operation in the civil uses of atomic energy between the United States and Euratom was signed on November 8 in Brussels. The major objective of the agreement is to bring into operation in the Community in the next five to seven years approximately one million electrical kilowatts of nuclear power capacity, using reactor types developed in the United States. It is expected that the provisions for wide dissemination of information under the programme will provide industrial organizations in the Community and the United States with valuable engineering experience, and technological and economic data concerning the operation of nuclear power plants in Europe under conditions that will be nearly competitive with conventionally fuelled plants. The capital cost of the joint nuclear power programme, exclusive of fuel, is expected to be about 350,000,000 dollars. An integral part of the programme is a joint ten-year research and development project. During the first five years the Community and the United States will each contribute up to 50,000,000 dollars. Before the expiration of the first five years the participants will determine the financial requirements for the remaining five years and will undertake to procure the necessary funds for the programme.

Committee on Space Research

At its recent meeting in Washington the International Council of Scientific Unions established a Committee on Space Research (COSPAR), with the primary purpose of providing a means whereby the scientific community may use to maximum advantage the possibilities of satellites and space probes for scientific purposes, and exchange the results on a co-operative basis. On November 14 and 15 the Committee on Space Research held its first meeting in the rooms of the Royal Society in London. A constitution was drawn up for approval by the International Council of Scientific Unions, and the following executive committee was elected: *President*, Prof. H. C. van de Hulst (International Astronomical Union); *Vice-Presidents*, Prof. E. K. Fedorov (U.S.S.R. Academy of Sciences, Moscow), Prof. W. Albert Noyes, jun. (University of Rochester, New York); *Members*, Prof. Maurice Roy (International Union of Theoretical and Applied Mechanics), Prof. H. S. W. Massey (International Union of Pure and Applied Physics).

National Science Foundation Grant for U.S. National Observatory

The National Science Foundation has allocated 4 million dollars to the Association of Universities for Research in Astronomy, Inc. (AURA), for the construction of a solar telescope. These funds bring to a total of 7,545,000 dollars the amount that has been allocated so far for the erection and operation of a United States national astronomical observatory on Kitt Peak in the Quinland Mountains of south-western Arizona (see *Nature*, 181, 236; 1958). An additional 1 million dollars has been appropriated by Congress to the National Science Foundation for transfer to the Bureau of Public Roads for construction of a road giving access to the observatory site, which has been leased from the Papago Indians, in whose reservation it lies.

The solar telescope will be equipped with an 80-in. light-gathering flat at the top of the tower, and a 60-in. image-forming mirror, with a focal length of 300 ft. The instrument will thus be the largest solar telescope in existence, with about twice the focal length of the famous 150-ft. tower telescope at Mount Wilson. Stellar instruments at the observatory will consist initially of a 36-in. reflecting telescope to be made by Boller and Chivens, of South Pasadena, California, and an 80-in. high-speed reflecting telescope by Corning Glass Works, with auxiliary instrumentation.

Lunar Topography: Gift to the University of Manchester

The Geophysics Research Directorate of the U.S. Air Force, Cambridge (Mass.) Research Center, entered, as from November 1 of this year, into a contractual arrangement with the University of Manchester (through the European Office of the Air Research and Development Command in Brussels) to support in its Department of Astronomy an extended programme of topographic studies of the Moon. This emphasizes the current need for more accurate information on the heights and dimensions of lunar surface features than we possess to-day. A large part of such data as are now available go back to the work of amateur astronomers of the nineteenth century, and are based on visual measurements the accuracy of which leaves much to be desired. The Department of Astronomy at Manchester, under Prof. Zdeněk Kopal, proposes to increase this accuracy by filming sunrise or sunset over selected lunar regions, and triangulating for the topographical details of the landscape from measurements of the varying lengths of the shadows. This work was actually commenced two years ago by collaboration between the University of Manchester and the Observatoire du Pic-du-Midi in the High Pyrenees, which is well known for its superior seeing, and the photographic work done through the 24-in. refractor of the Observatory by kind permission of the director, Dr. Jean Rösch. The measurements and reductions of all films are to be made at Manchester under the supervision of Dr. Gilbert Fielder.

The ciné technique, pioneered by R. R. McMath, R. M. Petrie and H. E. Sawyer at the University of Michigan in the middle 1930's, has been elaborated in recent years at Manchester and has attained new standards of precision; its application to the Pic-du-Midi photographs makes it possible now to distinguish, on the Moon, objects of linear dimensions in excess of 500 yd., and altitude differences of the order of 20–30 yd. The programme of mapping the entire visible hemisphere of the Moon to this accuracy will probably occupy the Department of Astronomy at Manchester for the next five years, at a total cost of approximately 80,000 dollars.

Rowan Hamilton Bridge

On November 13, Mr. Eamon de Valera, Prime Minister of the Republic of Ireland, unveiled a tablet on Broome Bridge at Cabra, Dublin, to commemorate the invention of quaternions. The bridge has now been renamed Rowan Hamilton Bridge. The story of Hamilton and his bridge ranks with those of Archimedes and his bath and of Newton and his apple, as the Provost of Trinity College (Dr. A. J. McConnell) remarked in his speech at the ceremony, and it concerns a man of comparable intellectual stature. On October 16, 1843, Sir William Rowan Hamilton was walking with his wife along the Royal Canal from Dunsink Observatory to preside at the Council of the Royal Irish Academy when, on coming to Broome Bridge, the long-sought fundamental rules for quaternion algebra flashed upon his mind. Acting upon what he afterwards called an "unphilosophical impulse", he scratched the formulæ on the stonework with his penknife. The same afternoon he gave notice of his intention to read a paper on the subject at the Academy meeting on the following November 13—hence the date chosen for the unveiling. The tablet was erected by the Council of the Dublin Institute for Advanced Studies, of which the Right Rev. Monsignor P. Browne is chairman. Mr. de Valera, who is himself a mathematician well versed in Hamilton's work, has taken a keen personal interest in the project, which was carried on under the active direction of Prof. F. E. Hackett, chairman of the Governing Board of the School of Theoretical Physics of the Institute.

Hamilton's work on quaternions had widespread influence upon the development of mathematics, especially in America, and it was a pioneering step towards the subsequent far-reaching enlargement of algebra. While it is Hamilton's work in other fields that has had such a profound influence upon the whole form of modern theoretical physics, it would be scarcely possible to find in it, or in the work of any other theorist, anything more apt or evocative for a public memorial than the episode that has now been commemorated. The memorial in Dublin may be unique as one commemorating a particular discovery in mathematics, and must surely be unique as one inaugurated by the head of a Government who personally appreciates the significance of an achievement of this kind.

British Museum (Natural History): The Hedges Collection of British Moths

Among the more important acquisitions recently reported to the Trustees of the British Museum (Natural History) was the Alfred Vander Hedges collection of British moths presented by Mrs. Celia Hedges, in accordance with the wish of her late husband. The collection is a very extensive one, comprising about 20,000 specimens, and consists almost exclusively of specimens reared in captivity by Mr. Hedges. Some of the specimens had been reared in experiments in connexion with genetical studies in co-operation with the late Dr. E. A. Cockayne, whose collections are already the property of the Museum. Others are the result of his intensive collecting in the Isle of Man, as a consequence of which many species previously unknown in that Island were discovered to be present. The whole collection is in the most perfect condition.

The National Trust

The sixty-third annual report of the National Trust presented to the annual meeting on November 7 records a further increase of membership to 70,687 during the first five months of the year, but the figure is still short of the 100,000 the Council hopes to reach by January 1960, and only a membership consonant with its responsibilities can enable the Trust to exert its full influence for the preservation of the best of the countryside and Britain's finest buildings. The report refers to the need to dispel widespread misapprehension arising from the title 'National Trust', which tends to obscure the Trust's dependence on voluntary support. Emphasis is also placed on the changes in method which the Trust has had to adopt now that it is increasingly concerned with the impact of the public on the countryside. Its duty has often become one of control to preserve the countryside from damage by litter hooliganism or even the sheer wear of numbers on a limited area. The Trust has had to face unpopularity in some quarters in confining the public to footpaths on agricultural land, in strictly limiting caravans, tents and car parks to appropriate sites, and generally in regulating access to its open spaces. Certain changes in the administration of the Trust are being made in accordance with the recommendations of a special committee appointed to consider the subject, and the first regional secretary has been appointed. The Trust's nature reserves continue to prosper and are becoming increasingly important. The new mere at Wicken Fen has already attracted a large variety of ducks and waders; the eider is again breeding in the Farne Islands in ever-increasing numbers and 600 pairs of Sandwich terns are known to have nested at Blakeney, while figures for redshank and little tern were also well above the average.

Forest Products Statistics

With the completion of the decade of publication of the Yearbook of Forest Products Statistics, the Forestry Division of the Food and Agriculture Organization of the United Nations has decided that in view of the considerable progress that had been achieved in making the compilation more complete, more uniform and more accurate, it would be of value to revise the earlier issues, bringing the data as nearly in line as possible with the latest, and to publish a ten-year summary. The particular value of such a summary (World Forest Products Statistics: a Ten-Year Summary, 1946–1955. Pp. viii+197. Rome: Food and Agriculture Organization; London: H.M. Stationery Office, 1958. 15*s.*; 3 dollars) lies in its use for the study of trends, which have become so important with the rapid developments in production and use of timber in most parts of the world.

This development is continually in progress and is exemplified in the Yearbook for 1957 (Pp. vi+169. Rome: Food and Agriculture Organization; London: H.M. Stationery Office, 1957. 12*s.* 6*d.*; 2 dollars) by the provision of separate statistics for particle board (defined as a board "constituted from fragments of wood and/or other vegetable materials which have been comminuted and then consolidated by pressure, heat, etc., with or without binders and supplementary materials"). World production of these materials rose from less than 500,000 metric tons in 1955 to 705,000 metric tons in 1956, more than half being in the United States and Germany, and there is every indication that there will be continued expansion in the future; there are factories in the United Kingdom, but the total output is still small. Another change in this issue is the inclusion of estimates for the relatively few countries from which returns have not been received; without these, regional totals can be very misleading.

Progress in Geology

The present century has, perhaps, been more notable for advances in techniques and in the accumulation of detailed knowledge than in the formulation of radically fresh ideas in geology, and it is of interest to inquire what general trend is discernible in the interpretation of the Earth's history as a result of these advances. Prof. L. Hawkes, in his anniversary address to the Geological Society of London (*Quart. J. Geol. Soc.*, 133, 309; 1958), considers that vindication of the Lyellian doctrine of uniformitarianism has been the central theme of progress in geology in the past fifty years. During this period determination of the age of minerals by radioactive decay methods has underlined the immensity of the geological time-scale. At the same time, precise geodetic measurements have disclosed crustal movements in various parts of the world to-day proceeding at rates which, bearing this time-scale in mind, are adequate to account for the huge deformations of the past, thus extending the principle of uniformitarianism to the field of tectonics. Not only must earlier ideas on the catastrophic nature of mountain-building processes be discarded, but the presumed world-wide synchronism of mountain-building periods may also be seriously challenged as isotopic methods of dating and correlating sediments are improved. There may be no 'pulse of the Earth'. Normal sedimentary rocks were being formed at least 3,000 million years ago, and there is now direct fossil evidence for the existence of simple forms of life more than 2,000 million years ago. Conditions on the Earth's surface seem to have been much the same as they are to-day over a much longer span of time and in more ways than would generally have been believed possible fifty years ago.

Science Masters' Association

THE annual meeting of the Science Masters' Association is to be held in University College, Gower Street, London, W.C.1, during December 30–January 2. The programme includes the following lectures: "The Scope of Modern Physics", by Prof. H. S. W. Massey; "Principles of Organic Chemistry", by Prof. E. D. Hughes; "Algal Pigments", by Dr. G. E. Fogg; "Industrial Applications of Radioisotopes", by J. L. Putman; "Learning in Octopuses", by Prof. J. Z. Young; "Opportunities for Students in Colleges of Technology", by Dr. J. Topping; "Old Metals and New Valencies: the Stabilization of Unusual Valency States", by Prof. R. S. Nyholm; "Techniques in Nuclear Physics", by Dr. E. H. S. Burhop; "New Engineering Problems in Aeronautics", by H. G. Conway; "The Study of Ripples by the Schlieren Method", by W. Llowarch; "Molecular Spectra and Molecular Structure", by Dr. D. J. Millen; "Some Problems in Teaching Science in Large Secondary Schools", by R. J. Scammell. Accommodation for members at the meeting will be provided at Queen Elizabeth College, Kensington, W.8; Canterbury Hall and Bentham Hall, both in Cartwright Gardens, W.C.1. Further information can be obtained from the annual meeting secretary, Mr. W. H. Dowland, 93 Westbourne Road, West Hartlepool, Co. Durham.

Imperial Chemical Industries Transfer Scholarships

LAST year, thirty-three university students who decided that they wanted to change from the arts to science were able to do so by taking advantage of the Imperial Chemical Industries transfer scholarship scheme. Most of these students have now passed their examinations and have entered their chosen science honours school. Of the twenty-seven transfer scholars elected in 1956, more than 80 per cent successfully made the change from arts to science. These encouraging figures have persuaded Imperial Chemical Industries to extend its guarantee of scholarship funds for a further two years to the universities which originally co-operated in the scheme. These are Oxford, Cambridge, Liverpool, Imperial College of Science and Technology, London, and King's College, Newcastle. At Oxford the number of scholarships available will be extended so that, in common with Cambridge, every college will have a transfer scholarship in its gift. Scholarships not taken up can be passed on to other colleges which have more than one suitable candidate. In all, sixty-five of these scholarships are now available, the universities co-operating also including Birmingham, Bristol and Sheffield, which came into the scheme a little later.

University News: Belfast

THE following appointments have recently been made: Dr. C. L. Wilson, to a personal chair in analytical chemistry; Dr. R. B. Welbourn, to a personal chair in surgical science; Dr. P. J. B. Clarricoats, to a lectureship in light electrical engineering; Dr. P. C. Elmes, to a lectureship in therapeutics and pharmacology.

London

THE following have been appointed to University readerships in the subjects indicated: Mr. J. R. D. Francis, lecturer at the Imperial College of Science and Technology (fluid mechanics); Dr. R. W. Tiffen, lecturer at Birkbeck College (applied mathematics); Mr. W. J. Tulley, lecturer at Guy's Hospital Medical School (orthodontics). Dr. Emrys Jones, lecturer in geography at the Queen's University of Belfast, has been appointed to the University readership in social geography tenable at the London School of Economics and Political Science.

Announcements

THE Christmas Lecture arranged by the Institution of Electrical Engineers will be held in the Institution's rooms on December 31, at 3 p.m., when Dr. E. R. Laithwaite (University of Manchester) will speak on "Invention and New Machines". Admission to the Lecture is by ticket, obtainable, free of charge, from the Secretary, Institution of Electrical Engineers, Savoy Place, London, W.C.2.

THE annual Christmas lectures organized by the Royal Photographic Society for a juvenile audience, which will be given in the Department of Photography at the Regent Street Polytechnic, London, W.1, at 2.30 p.m. on January 1 and 2, 1959, will be on "Picture Making in Photography". Tickets are free, and can be obtained on application to the Secretary of the Royal Photographic Society, 16 Princes Gate, London, S.W.7.

THE annual conference of the Geographical Association will be held in the London School of Economics, Houghton Street, London, W.C.2, during December 30, 1958–January 2, 1959. Further details can be obtained from the honorary conference organizer, Mr. R. C. Honeybone, University of London Institute of Education, Malet Street, London, W.C.1.

THE Palæontology Association will hold a discussion meeting on "Micro-palæontology" in the Department of Geology, Sedgwick Museum, Cambridge, on December 12 and 13. Sixteen papers on spores, ostracods, conodonts and foraminifera will be read, and there will also be a large number of exhibits. Further information can be obtained from Dr. Gwyn Thomas, Department of Geology, Imperial College of Science and Technology, London, S.W.7.

THE Physical Society is organizing a conference on "Problems of Collective Motion", to be held at the University of Birmingham, on January 2 and 3, 1959. Informal discussions will follow introductory talks on gaseous plasma; plasma problems in the electron theory of metals; liquid helium and superconductivity; and collective problems in nuclear dynamics. The conference is open to non-members of the Physical Society on payment of a fee of one guinea. Further information can be obtained from Miss E. Mills, Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

THE following scholarships will be offered by the Institution of Naval Architects for competition in 1959: Denny Scholarships in Naval Architecture and Naval Engineering: £175 per annum, tenable for four years at the University of Glasgow, and open to British subjects less than nineteen years of age who have not yet begun an apprenticeship, or served not more than one year of it with Messrs. William Denny & Bros., Dumbarton. Parsons Scholarship in Marine Engineering: £175 per annum, open to British apprentices or pupils in marine engine works or the Royal Dockyards less than twenty-one years of age. Yarrow Scholarship in Marine Engineering: conditions as for Parsons Scholarship in Marine Engineering. Further particulars can be obtained from the Secretary, Institution of Naval Architects, 10 Upper Belgrave Street, London, S.W.1.

THE COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA

CONSTITUTED in 1926 by Act of the Australian Parliament, the Council for Scientific and Industrial Research grew steadily and, in 1949, its name was changed to the Commonwealth Scientific and Industrial Research Organization. This led to little change in its policy and methods of work, the Organization being divided into a number of Sections and Divisions, each of which enjoys a large measure of autonomy in the conduct of its scientific programme. The Divisions and Sections cover a very wide field of scientific activity with the exception of atomic energy and human medical science; considerable activity is directed to veterinary science. The Organization is not a Government department, but is a Government 'instrumentality' which draws approximately 80 per cent of its revenue directly from the Treasury. The remainder is provided by other Commonwealth 'instrumentalities', such as the Snowy Mountains Authority, and certain industrial groups which finance investigations of interest to these bodies.

The work of the various Divisions and Sections is reflected in a remarkable series of publications, each of which does credit to an Organization which is very well administered and is doing so much for the development and spread of scientific inquiry throughout the southern hemisphere. These publications include journals, bulletins, technical papers, monographs, land research series and soil publication series.

Among the more special journals are the *Australian Journal of Physics*, the *Australian Journal of Chemistry*, the *Australian Journal of Applied Science* and the *Australian Journal of Biological Sciences*, each of which is issued quarterly; the *Australian Journal of Agricultural Research* is published six times a year. Not issued at regular intervals are the *Australian Journal of Marine and Freshwater Research*, the *Australian Journal of Botany* and the *Australian Journal of Zoology*. The *Journal of Biological Sciences* differs from the *Journals of Botany* and *Zoology* in paying more attention to the experimental sciences; the botany and zoology journals are more concerned with the descriptive phases.

The Australian Academy of Science co-operates with the Organization in maintaining appropriate standards in the eight journals mentioned above, and the journals are open to receive contributions from research workers, irrespective of country or of the establishment to which they are attached.

In a recent issue of the *Journal of Biological Sciences* (10, No. 4), for example, articles were included dealing with the physiology of pea fruits, with special reference to changes in sugars and phosphate compounds in the developing seed; the effects of auxins on the binding of pectin methylesterase to cell-wall preparations; the lag period in auxin-induced expansion of storage tissue and coleoptiles; the effect of developing embryos on plant viruses; studies on the seed transmission of plant virus diseases; the metabolism of *Ascaris lumbricoides* ovaries; the dose response to bovine plasma albumin in mice and the simulation of genetic systems by automatic digital computers.

A recent volume of the *Journal of Botany* (5, No. 2) contains descriptions of floral histogenesis in the Cyperaceae; the regeneration of severed pea apices; the soil moisture patterns produced by rainfall interception and stem-flow in Dark Island heath; the high mountain vegetation in Australia; and the nature and distribution of rain-forests in New South Wales.

The *Journal of Agricultural Research* is a medium for the publication of investigations relating to plants, soils and domestic animals, covering the physical, chemical and biological aspects in this field. Examples of the wide range of topics investigated is shown by a list of topics taken from a number published some months ago (8, No. 6). The topics included air-tight storage of grain and its effects on insect pests; the pruinose scarab (*Sericesthis pruinosa* Dalman) and its control in turf; the renovation of *Phalaris* pastures with special reference to nitrogen and sulphur relationships; quantitative inheritance in lucerne with particular reference to winter yield; a comparison of three low-persistence viruses of the strawberry; the effect of volatile fatty acids, lactic acid, and ammonia on rumen *p*H in sheep; the effect of diet on individual volatile fatty acids in the rumen of sheep, with particular reference to the effect of low rumen *p*H and adaptation of high-starch diets; the tolerance of sheep to sodium chloride in drinking water; a study of wool production per unit area of skin in Australian merino sheep; the equatorial light environment and its effect on the coat of European cattle; reactions of calves to infestation with the stomach worm; strategic dipping for control of the cattle tick, *Boophilus microplus* (canestrini), in south Queensland; and sperm transport in the fowl.

The *Australian Journal of Applied Science* is, as the name suggests, concerned with the publication of results of original investigations in the broad field of applied science. A recent issue (8, No. 4) contains articles dealing with edge stresses in thin shells of revolution; precision charge comparison for the standardization of X-ray dosimeters; heating of surfaces by buried pipes; heat transfer to liquids boiling inside tubes; an improvement of the vacuum vapour pump with theoretical and practical consequences; laboratory pressure-leaching techniques; slagging of refractories by brown coal ash; and a study of the infra-red absorption spectra of soils.

Besides these more 'formal' journals, the Organization issues a number of other publications dealing with applied researches into particular materials or topics. The Food Preservation and Transport Division, for example, publishes a quarterly journal in which the results of practical investigations of immediate topical interest are set out. The use of various plastic materials for pre-packaging fresh fruit and vegetables, for example, was investigated in 1957, and firm recommendations were made which would be of value not only to those in the trade but also to housewives. Other topics investigated by the Division in recent years include the internal corrosion of food cans; anthocyanin pigments in foods; glass-like deposits in canned foods; the quality of dried-egg products ; the handling and care of fresh unfrozen fish ; discoloration of canned pears ; and the estimation of dissolved tin and iron in canned foods.

The Coal Research Section also produces its own journal containing articles of direct value to those particularly concerned with the large-scale use of coal or its products. Besides articles describing the mineral matter in Australian coals and how coke is formed, the May 1958 issue contains the report of a symposium called to consider how iron castings in foundries could be improved through the use of improved qualities of foundry coke. Articles in other issues of the same journal describe the sulphur minerals in various Australian coals, the methods of cleaning coal and the industrial possibilities of Australian coal tars.

That the Organization is genuinely concerned to see that the results of its many researches are widely disseminated as quickly as possible is shown by two other publications. The Forest Products Division publishes a monthly news-letter which is available to all members of the timber trade and timber users. Topics discussed in some of the latest letters include "How Strong are Wooden Fence Posts ?", the right Australian timbers to use for making clothes pegs, water-borne preservatives for fence posts, and low-pitch roof trusses.

The Agricultural Research Liaison Section produces a most attractive periodical called *Rural Research in C.S.I.R.O.*, which provides a summary of recent research and explains its practical significance. Among subjects which have been dealt with over the past year are the following : Kimberley horse disease ; inbreeding merinos ; tolerance of sheep to salt ; plant nematodes ; renovating *Phalaris* pastures ; preserving fence posts ; making clouds rain ; crops and pastures for northern Australia ; time losses in haymaking ; scrapie in imported sheep ; rabbit control in New Zealand ; durable pleats in wool ; damage of rice by ducks ; the sheep blowfly ; roundworms of cattle ; 'snorter' dwarfism ; changes in pasture soils ; soil salinity ; the portable soil-moisture meter and the spear grass problem.

Under the able chairmanship of Sir Ian Clunies Ross, assisted by the deputy chairman, Dr. F. W. G. White, and the vigorous executive direction of Dr. S. H. Bastow, the Commonwealth Scientific and Industrial Research Organization has already gathered sufficient momentum to ensure its ever-increasing usefulness in solving the many physical and biological problems which confront Commonwealth countries in the southern hemisphere.

Dr. N. S. Noble, general editor, is to be congratulated on the standard and style of the Organization's publications.

PULP AND PAPER RESEARCH INSTITUTE OF CANADA

NEW LABORATORIES

THE new laboratories of the Pulp and Paper Research Institute of Canada at Pointe Claire, Quebec, were officially opened on September 18 by the Hon. William Hamilton as representative of the Government of Canada. Other speakers included Dr. Lincoln R. Thiesmeyer, president of the Pulp and Paper Research Institute of Canada ; Dr. David L. Thomson, dean of the Faculty of Graduate Studies and Research of McGill University ; and Mr. Fred L. Allen, executive vice-president of the Canadian International Paper Company and chairman of the Institute's board of directors.

Few people employed in the pulp and paper industry of the world, be it in mill management or research, can fail to become aware at a very early stage of their career of the importance of both the fundamental and the applied research carried out at the Pulp and Paper Research Institute of Canada, the research institution jointly sponsored by the Canadian Government, the pulp and paper industry of Canada as represented by the Canadian Pulp and Paper Association, and the Royal Institution for the Advancement of Learning of Canada.

The Institute started as a branch of the Forest Products Laboratories of Canada in 1913, and in its early years was housed in part of two old buildings at the corner of the McGill campus. In 1920 the Canadian Pulp and Paper Association joined its own research activities with those of McGill and the Government and soon the rate and scope of the research activities made larger buildings necessary ; these were built on the same site and opened in 1929. In 1940 the work was consolidated by putting the programme under the supervision of a general director, overall guidance on policy being provided by a joint administrative committee. Finally, in 1950, it was decided to expand the programme still further, and the Institute acquired its present form as a non-profit-making educational and research corporation under Federal charter with a board of directors and a full-time management. To stabilize the financial backing needed for the large-scale research programme, most of the companies in the industry entered into renewable five-year contracts with the Institute in 1953, providing annual support proportionate to their tonnage of production. At the same time the need for greatly enlarged headquarters became urgent ; by 1955 plans for the new laboratories at Pointe Claire, near Montreal, had been drawn up, and the Government agreed to build and equip the new building to the Institute's specifications, the industry contributing part of the equipment. For the time being, the building on the McGill campus will continue to be used for postgraduate studies, some fundamental bench-type research, the main library, etc., but it is hoped that in due course these activities can be transferred to the new site, as funds and space become available.

The Institute has a full-time staff of 168, 131 of whom are technical and scientific personnel. Twenty-two graduates are at present participating in the thesis programme. The operating budget for 1958–59 is 1,500,000 dollars, one million dollars coming from Maintaining Member Company contributions, 100,000 dollars from a continuing annual grant of the Canadian Pulp and Paper Association and the remainder as revenues from sponsored research contract projects, chemical and physical testing and consulting services.

The research programme of the Institute covers a vast field, including the study of the chemical structure and properties of cellulose and polysaccharides, physico-chemical and chemical engineering investigations, for example, physico-chemical studies of paper-making fibres and flow and aggregating properties of suspensions, pulping and bleaching studies, disposal of waste liquor, paper formation, instrumentation and pulp and paper testing, analytical methods and the application of photography and microscopy in research. Thus, the Institute acts as a centre for fundamental research, supplementing the research organizations of individual companies. It stimulates and assists in the postgraduate training of students of McGill University, who are working for higher degrees in science and engineering, especially students whose theses deal with subjects of interest to the industry. Two hundred and fifty Ph.D. students have participated in this programme over the years, including a large number of students of chemistry and some chemical and mechanical engineers; it is hoped that in future students of physics, biophysics and biochemistry and biology will increasingly participate.

The Institute also conducts research at the request of individual companies, groups of companies and other sponsors in allied industries.

At the same time, the Institute acts as a clearing house and distribution centre for technical and scientific information, which is published in the form of monographs, bibliographies, translations, and critical reviews. Work carried out at the Institute is published in technical reports and articles in the periodical literature.

The different aspects of the work being done at the Institute were fully taken into account when planning the new building. Two-story blocks house the department of physics, physical measurement and electron microscopy; the mechanical engineering development sections with the adjacent chemical pulping pilot plant; the department for woodlands research, chemical pulping and fibre research, photography and microscopy and chemical analytical services, etc.; there are a refiner and stock-preparation building and a bleaching and small-scale pulping laboratory together with all the ancillary services such as woodworking, sheet metal and pipe-fitting shops, engineering offices, control laboratories, administrative offices with the branch library and a printing and duplicating shop. The buildings were designed to permit unrestricted expansion of any major section without interference with any other, this requirement being met by arranging the building in four wings each of which houses a particular type of operation. The design also permits working space to be redistributed both horizontally and vertically.

To work in buildings specially designed for the purpose will greatly assist the staff of the Institute in carrying out their investigations, and all workers in the industry can thus look forward to receiving an ever-increasing flow of valuable data and information.

S. LAMMLE

SCIENCE AND CIVILIZATION

IN his Sir Henry Simpson Newland Oration before the Australian Medical Congress at Hobart on March 5, now published in the *Australian Journal of Science* (20, 251; 1958), the Prime Minister of Australia, the Right Hon. R. G. Menzies, dealing with "Modern Science and Civilization", examined the place of science, including military science, in modern society. Great talent in science is not the monopoly of any one country, and Mr. Menzies, agreeing that the U.S.S.R. is training a greater proportion of its population in applied science than is any other country, pointed out that the Soviet Union could conscript young men and women into science at will and that there was reason to believe that Soviet technological man-power was excessively concentrated upon military production. The Soviet achievement with artificial Earth satellites should therefore be regarded with a sense of balance and not as a tragedy. Even if some ultimate military purpose lies behind the recent exercises, it simply means that the statesmen of the free world must seek both to maintain such a power of destruction in war as would deter aggression and also continue their efforts to persuade the Communist Powers that the immense possibilities of applied science should be increasingly diverted to the service of the peaceful needs of men and women.

A main theme of Mr. Menzies's address was to emphasize the need for a balanced judgment and to show how easily our own standards of civilization could be distorted. Scientists, he remarked, are not a race apart. They are citizens, bound to a social consciousness and social duties, and cannot, any more than non-scientists, stand apart from the great moral issues. The liberty of the scientist to pursue his chosen study is part of that great structure of self-governing and self-disciplined freedom which the institutions of the democratic world had painfully but persistently developed. That liberty is under challenge, and the scientist has a special interest and responsibility to share in its defence. Natural philosophy cannot make its best contribution to life unless accompanied by a moral and mental philosophy to give it balance. It would be calamitous for the specialist to contract out of the formulation and expression of a social consciousness which recognizes the paramount need to preserve the spirit and institutions of freedom.

After referring to some of the achievements in research of the free peoples, besides which those of the Communist world are insignificant, Mr. Menzies insisted on the need to take long views if civilization is to advance. It is a short answer to the Soviet achievements in the *Sputnik* field to suggest that we need only produce more and better scientists. The crucial question is for what purpose such scientists are to be used. We must recognize the danger of adopting Soviet methods to achieve Soviet results. Provision for scientific defence is for us solely a means of preserving democratic freedom and civilized individual rights. If such provision came to be regarded not as a free national effort but as something requiring the abandonment of freedom and acceptance of authoritarian control, we would have abandoned the case against Communism in the very effort to maintain that case.

Pointing out further that without more scientists and more scientific research the material future of the free world could not be assured and enlarged, Mr. Menzies also referred to the danger here of confusing ends with means. Whether scientific advance means human salvation or a new and complicated form of technological slavery depends on our character, our broad intelligence and our wise and understanding judgment. We must be ready to meet aggression with purpose as well as vigour, but our social policies and particularly our educational policies must be so devised as to encourage sanity and responsibility, and discover blundering accident. Psychologically, the true answer to the threat of war must be found in the improvement of the nature of man himself. The true end to be served is the enlargement of the human mind and spirit. We need more scientists, but also more scholars; more scholarly scientists; more scientific scholars; more historians and philosophers and poets. If science is truly to serve the cause of civilization it will be because the people who use the advances of science have grown to use them in a civilized way. Not all the most brilliant successes in laboratories and factories and fields would make a nation great in the eye of history if it had failed to enthrone the human spirit and to set about it knowledge, and justice, and patience, and understanding.

RADIO RESEARCH, 1957

While research work devoted to various aspects of radio wave propagation is vital and should continue, it is recommended by the chairman of the Radio Research Board in his annual report[*] that the research programme of the Department of Scientific and Industrial Research Radio Research Station at Slough during the next five years should be broadened in scope, to ensure that experience is gained and progress made with other important topics. So far as possible, new fields of research should bear directly on practical applications, and examples include molecular amplifiers and oscillators, and the design and properties of microwave aerials. The radio transmissions from artificial Earth satellites, orbiting so that the source is sometimes within and sometimes above the ionosphere, already have provided a valuable new tool for examining ionospheric propagation, and frequency and directional measurements on the first two U.S.S.R. satellites were made at Slough. More accurate position data for the satellites are awaited before a full analysis of the results obtained is possible.

The work of the Radio Research Station is described in detail in the report of the Director, special emphasis having been given to items directly connected with the International Geophysical Year. In addition to the ionospheric observatories at Inverness, Port Stanley (Falkland Islands), Singapore and Slough, equipment designed or built at the Radio Research Station has been in operation at Halley Bay (Antarctica), Ibadan (Nigeria) and Port Lockroy (Grahamland). The Station has also been designated one of the four World Data Centres for the collection of all International Geophysical Year ionospheric data, the others being at Boulder (Colorado), Moscow and Tokyo. Data from about one hundred stations are sent directly to Slough, while those from some two hundred other stations arrive through the other three Centres.

Routine measurements over the current sunspot maximum period have yielded the highest monthly mean values of $F2$ critical frequency ever recorded over twenty-six years. This experience suggests that in considering the allocation of appropriate frequencies for short-distance radio communication, a frequency of 60 Mc./s. may be taken as the upper limit ever likely to be used in normal F-region propagation. Work has continued on the selection of a suitable ionospheric index of solar activity, primarily as an aid to forecasting propagation conditions. A preliminary investigation suggests that it might be possible to produce a permanent set of charts which would give the critical frequency at any point in the world for any phase of the sunspot cycle (defined in terms of the ionospheric index of solar activity), and which ultimately should render many of the current routine ionospheric measurements unnecessary.

Work on oblique-incidence radio propagation in the high-frequency and very high-frequency bands has continued. An investigation is being made into a possibility that commercial use may be made of the observed lateral deviations of the propagation direction from the great circle path for frequencies of the order of 20 Mc./s. when the latter mode has faded out. This phenomenon is not fully understood, but is thought to be due to some form of ground scattering. The value of the plan-position-indicator 'back-scatter' technique in the investigation of propagation modes to long distances is now established, and experiments are being made to compare the field-strength for forward propagation on a frequency of 17 Mc./s. with that for scatter reception from the same range. Another field of investigation is the forward-scattering of very high-frequency signals in the E-region, and associated with this form of propagation are the strong momentary enhancements of signal which are attributed to reflexions from sporadic meteors.

Long-distance 'scatter links' for ultra high frequencies, by which communication is obtained through forward scatter in the troposphere, are also being investigated at the Radio Research Station. Experiments are in progress on frequencies of 53, 1,370 and 3,500 Mc./s. used over different path-lengths, with the view of clarifying the problem of whether the propagation is maintained as a result of random fluctuations of refractive index caused by turbulence throughout the whole troposphere, or is due to variations of refractive index in relatively restricted layers of the troposphere. As an aid to this study, direct measurements of tropospheric refractive index have been initiated and have so far yielded encouraging results. Work has continued on the measurement of atmospheric radio noise, and equipment has been developed for routine use during the International Geophysical Year for measuring the detailed features of the noise in the frequency-range 15 kc./s.–30 Mc./s. with the view of elucidating the mechanism whereby individual lightning flashes give rise to noise at different frequencies.

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[*] Department of Scientific and Industrial Research, Radio Research 1957: The Report of the Radio Research Board and the Report of the Director of Radio Research. Pp. iv+43+4 plates. (London: H.M. Stationery Office.) 3*s*. 6*d*. net.

Observations of the phase and amplitude characteristics of very low-frequency waves (10–20 kc./s.) reflected from the ionosphere are also described in "Radio Research 1957". The experimental work, which bears directly on the application of such waves for navigational aids over long distances, is being supplemented by theoretical work on the propagation of very low-frequency waves.

In addition to the work on radio propagation over a wide frequency-range, the Department is engaged on the development of radio-frequency power measuring standards, and research into semi-conductors and magnetic and dielectric materials. Work on germanium has been superseded by that on silicon filaments and commercial transistors, with particular reference to performance at very high radio-frequencies. The magnetic properties of a wide range of ferrites and other metal oxides and their applications to microwave measurements are being investigated.

Some of the work described in the report is undertaken, under contract with the Department, at various universities. A list of papers published during 1957 is given as an appendix. GEOFFREY M. BROWN

ECOLOGY OF SOIL FUNGI

THE growth, activities and interrelationships of fungi in soil provided the basis for a symposium on "The Ecology of Soil Fungi" held at the University of Liverpool during August 19–21. The meeting, attended by ninety scientists from thirteen countries, was divided into six sessions, which were presided over, respectively, by Prof. N. A. Burges (University of Liverpool), Dr. P. W. Brian (Imperial Chemical Industries, Welwyn), Dr. J. Harley (University of Oxford), Prof. J. Guillemat (École National d'Agronomique, Grignon), Prof. J. Ziemiecka (Institut Uprawy, Pulawy, Poland) and Dr. H. Katznelson (Canadian Department of Agriculture, Ottawa). Each session included a review of one aspect of the subject and four or five shorter papers: most of the twenty-eight papers presented were circulated before the symposium and this undoubtedly contributed greatly to the very lively discussions.

Review papers by Dr. J. H. Warcup (Waite Agricultural Institute, Adelaide, read by Dr. Parkinson and J. S. Waid (Fisons, Levington) dealt, respectively, with the isolation and estimation of activity of fungi in soil and the effect of environmental conditions on fungal growth in soil. Synecological investigations which were afterwards discussed included: the fungi associated with pine litter and couch grass debris (Dr. D. Parkinson and B. Kendrick, University of Liverpool); the distribution of Chytrids in lake muds and soil (Dr. L. G. Willoughby, Fresh Water Biological Association, Ambleside); the microflora of sandy soils in the Sahara (Dr. J. Nicot, Natural History Museum, Paris); the fungal flora of tidal mud flats before and during colonization by *Salicornia stricta* (Dr. G. J. F. Pugh, University of Nottingham); the growth of fungi in forest and grassland soils (Dr. R. H. Thornton, Soil Bureau, Wellington, New Zealand, read by Dr. Parkinson); and the rhizosphere flora of *Abies* of different ages (Dr. R. Moreau, École Nationale de Médecine et de Pharmacie, Besançon). During the course of these papers and the discussions, the need for a greater knowledge of the origin of fungal isolates was emphasized. The use of the soil dilution plate count method, a subject of some considerable debate, was ably defended by Prof. J. Montegut (École National de Horticulture, Versailles), and an account of the use of this method in studies of the effects of nitrogen, phosphorus and potassium on soil fungi was submitted by Profs. J. Guillemat and J. Montegut. Dr. E. H. Garrard (Ontario Agricultural College) surveyed the detailed work on *Streptomyces scabies* at Guelph. Direct-observation studies of *Verticillium albo-atrum* in soil and tomato roots were described by Dr. G. W. F. Sewell (East Malling Research Station), and Dr. H. Tribe (University of Cambridge; read by Dr. S. Hepple, National Institute of Agricultural Botany, Cambridge) discussed his observational work on the decomposition of buried cellulose film.

A review by Dr. Brian of the antagonistic and competitive mechanisms limiting survival and activity of fungi in soil was followed by an account of antagonism as the background in which fungi live (Dr. D. Park, University of Manchester), and a description by Dr. R. Barton (University of Manchester) of investigations of substrate colonization by *Pythium mamillatum* under different conditions. Drs. A. G. Winter, F. Schonbeck and H. Peuss (Botanische Abteilung Madans, Köln Merhiem) discussed biotic factors, with reference to 'hyphospheres' and mycorrhizæ, affecting the development of soil fungi. Soil fungistasis, which Dr. Brian also included in his survey, was the subject of a paper by Dr. C. G. Dobbs, who reviewed some methods of study developed at the University College of North Wales, Bangor. Drs. Dobbs and J. Bywater (Bangor) described a seasonal variation in fungistasis in certain soils, and Dr. R. M. Jackson (Rothamsted Experimental Station) discussed the effect of living roots on the germination of fungal spores in soil.

Prof. Burges, in his paper "Dynamic Equilibrium of Soil Populations", discussed the effects on the soil micropopulation of seasonal fluctuation in depositions of organic matter. The uses of radiocarbon in studies on cellulose and lignin breakdown were described by Dr. J. Mayandon and Prof. P. Simonart (University of Louvain), while problems associated with the isolation of humic acid and its utilization as a nutrient by fungi were the subjects of a paper by Prof. Burges and Miss P. M. Latter. Certain aspects of fungal physiology in relation to soil studies were reviewed by Dr. Harley, whose paper was followed by accounts of the use of physiological methods, relating to oxidative metabolism, in mycological studies (Dr. D. Boulter and H. M. Hurst, University of Liverpool) and a demonstration by Dr. M. E. K. Henderson (Macaulay Institute, Aberdeen) that a number of fungi are able to decompose molecules related to lignin. Prof. C. G. C. Chesters (University of Nottingham) reviewed problems associated with the decomposition of organic matter in soils and stressed that all the different organisms concerned should be considered.

Dr. Katznelson, in an evening lecture, surveyed the work of the Bacteriology Division of the Canadian Department of Agriculture on rhizosphere problems. The ecological events in the rhizosphere and the general health of the plant were discussed in the light of the results of these studies.

Demonstrations, which were available for inspection throughout the period of the symposium, included an exhibition of the use of tracer techniques with special reference to studies of fungal growth in soil (Dr. E. Grossbard, Grassland Research Station, Hurley), the screened immersion plate technique (Dr. Thornton), and examples of soil sections prepared by a resin impregnation method (Dr. S. Hepple and Prof. Burges). The other exhibits were concerned with mycorrhizal studies. Slides and figures illustrating internal and external mycelial phases of vesicular-arbuscular endophytes associated with grass roots were presented by Dr. T. H. Nicolson (University of Nottingham), and Dr. B. Mosse (East Malling Research Station) demonstrated a method of obtaining pure inocula of an *Endogone* sp. capable of causing vesicular-arbuscular mycorrhizal infections: typical infections produced in apple, strawberry and onion roots were shown. Dr. D. G. Downie (University of Aberdeen) demonstrated strains of *Rhizoctonia solani*, pathogenic to potato, wheat and cauliflower, which stimulated embryo development of *Orchis purpurella*, and Dr. I. Levisohn (Bedford College, London) showed the growth of mycorrhizal mycelia on sterilized litter.

It is a pleasure to record the generous hospitality of the University of Liverpool and the excellent organization of this most informative and enjoyable meeting. The organizers are preparing the full proceedings of the symposium for publication by the University of Liverpool Press.

G. J. F. Pugh
G. W. F. Sewell

PHYSICS OF ICE MOVEMENT

A SYMPOSIUM on the "Physics of Ice Movement" was held at Chamonix during September 16–24. It was organized by the International Association of Scientific Hydrology for its daughter Commission for Snow and Ice, and was attended by some eighty-five glaciologists from fifteen countries. The work of the symposium was greatly facilitated by the feat of the secretary of the Association, Prof. L. J. Tison, in publishing the forty-one papers submitted for the symposium in time for the opening session*. The president of the Commission, Prof. R. Finsterwalder (Munich), presided over the symposium, and Prof. A. Bauer, one of the vice-presidents, organized the details; despite poor weather, he managed to arrange two whole-day excursions of great glaciological interest as well as twelve working sessions. It is, of course, impossible to summarize all the papers here, and I will only try to give some impression of the material presented in the wide range of relevant subjects discussed, which ranged from the deformation of single crystals of ice to the behaviour of the Antarctic ice sheet.

Prof. U. Nakaya (Sapporo, Japan) reported the results of some very beautiful tests performed on single crystals of ice of great perfection derived from an Alaskan glacier. Rectangular bars cut from these crystals in various orientations had been deformed by bending, and the resulting deformation studied by shadow photography, which reveals the glide planes, and by polarized light, to determine changes in crystal orientation. All the phenomena of gliding and low-angle boundaries observed in hexagonal metals are to be seen, and the geometry of the deformation, deduced by Nakaya, was shown by Dr. J. F. Nye (Bristol) in the symposium to have a close relation to the theory of deformation by continuous distributions of dislocations. The flow law for ice single crystals was discussed by Dr. T. R. Butkovich and Dr. J. K. Landauer (Snow, Ice and Permafrost Research Establishment, United States), who found that for single crystals, like polycrystalline aggregates, the relation between minimum strain-rate and stress can be well represented by a power law for stresses around 1 bar. They used shear tests, and found that if the crystal is oriented for easy glide on the basal plane, the flow is considerably faster than for polycrystals, whereas if the specimen is oriented so that no glide on the basal plane is possible under the applied stress, then the minimum strain-rate is of the same magnitude as that of polycrystals. Butkovich and Landauer also reported results of tests on polycrystalline ice, and further tests of this kind were reported by Prof. S. S. Vyalov (U.S.S.R.) and by Dr. S. Steinemann (Neuchâtel, Switzerland). They all confirmed that a power law represents the data well over a range of strain-rates from 10^{-9} to 10^{-5} sec.$^{-1}$, but at the limits of this range there are signs that the law ceases to hold, in the sense that the power decreases for the low strain-rates and increases for the high ones. Steinemann also found that he could plot a similar power law for the final strain-rate to which the specimen settles down (as opposed to the minimum rate). In this state the ice is recrystallizing during the creep, and it is of particular interest that he has results for both compression and shear tests so that the relations usually assumed to hold between the results of these two types of stressing system can be tested. He finds that the relations are not obeyed, and that the disagreement is particularly bad in the case of the final rate—a result which is perhaps not so surprising when it is realized that the recrystallization is producing quite different textures in the two cases. Since, however, it is this final rate which is probably most relevant to the rate of flow observed in glaciers, this may well mean that glacier theories made with the usual assumptions are subject to some error. Dr. J. W. Glen (Birmingham) in his paper discussed what possibilities there might be for a flow law without making the assumptions in question.

Experiments on glaciers which have bearing on the mechanical properties of ice were reported by several authors. Dr. B. L. Hansen and Dr. Landauer (Snow,

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* Union Géodésique et Géophysique Internationale, Association Internationale d'Hydrologie Scientifique, Symposium de Chamonix 16–24 Sept., 1958. (Gentbrugge: Association Internationale d'Hydrologie Scientifique (61 rue des Ronces), 1958.) Pp. 394. 300 frs. belges.

Ice and Permafrost Research Establishment) used measurements of the rate of closure of a hole drilled 1,346 ft. into the Greenland ice sheet to deduce the flow law of the ice, and found results in good agreement with the laboratory work, and Dr. C. C. Langway of the same laboratory reported measurements on the pressure of bubbles in the cores removed from this drill hole which showed that the bubble pressures largely reflected the weight of the overlying ice. However, if the specimens were kept for one year before testing, the bubble pressure never exceeded a certain value, showing that bubbles of greater pressure than that, although they had survived intact the process of being brought to the surface in a core, had relaxed their pressure during the year, and microscopic examination showed small cracks spreading from these bubbles. A further series of mechanical tests on ice were reported by Prof. Nakaya, who has measured the resonant frequency and the damping of bars of ice from various sources as a function of temperature. Recent results which he reported in the symposium, but which are not in his submitted paper, show that the peaks in a plot of damping versus temperature depend critically on the ice used, peaks being present in glacier ice which are not present in single crystals, and laboratory ice being different again. Nakaya's interpretation of this in terms of such things as the mechanical properties of grain boundaries was challenged by Steinemann in the symposium, who suggested that perhaps proton movements associated with the boundaries might be responsible—thus emphasizing that ice, though in many ways similar to a metal, has its differences.

Steinemann also discussed the recrystallization structures of ice, as did Prof. P. A. Shumskiy (Moscow) and Dr. G. P. Rigsby (San Diego). Steinemann used the results of his laboratory tests to discuss the recrystallization and intragranular movements that occur in glaciers, Shumskiy distinguished six mechanisms of straining and their corresponding structures according to the magnitude and type of stressing, and Rigsby presented the results of observations of the preferred orientations found in glaciers and after laboratory tests. In a second paper, Steinemann discussed the applicability of laboratory tests made on ice at temperatures below the melting point to the discussion of the behaviour of temperate glaciers, which are at their melting point and therefore contain some liquid water. He has analysed the stability of the liquid phase theoretically, and concludes that water droplets will only be stable at the intersection between four grains. Thus, until a certain quite high percentage of the ice has melted, the temperate glacier will consist of essentially 'dry' ice with water droplets at four-grain intersections. These droplets will raise the effective stress on the rest of the ice somewhat, but not by a factor out of proportion to the fraction melted. As a result, Steinemann concludes that results of tests on cold ice can be applied to temperate glaciers without serious error.

Naturally, several of the papers were devoted to aspects of the theory of glacier flow. One of the main topics discussed here was the propagation of surges through glaciers. If a glacier develops a greater thickness in some part, as a result, for example, of a very snowy winter, a wave of increased thickness will travel down the glacier at a velocity greater than the velocity of flow itself. A paper on the theory of this phenomenon was published earlier this year in *Nature*[1], and at the symposium, Prof. L. Lliboutry (Grenoble) analysed the observations made on the Mer de Glace during 1891–95 by Joseph Vallot to test this theory. He showed that, although there was qualitative agreement in that a wave of increased thickness moved through the glacier several times faster than the flow velocity, the agreement was not quantitative, and he suggested various possibilities to account for this. His main suggestion was that the friction on the bed may not be completely accounted for on the current theories, but that at high speeds it may diminish considerably due to the inability of the ice to close up behind obstacles past which it has flowed. Dr. J. Weertman (Washington, D.C.) also presented a paper on the subject of surges in which he developed further the theory of their propagation, and in particular discussed the question of the change in shape of the surface of such a surge.

Another sort of wave on a glacier was discussed by Dr. Nye; the waves in question are the undulations which form beneath ice falls and which have a wave-length corresponding approximately to the flow in one year; they are often called wave ogives, and sometimes pressure arches, since pressure was assumed to be responsible for their formation. Dr. Nye has pointed out that in an ice fall where a high velocity is reached, accompanied by an extension of the ice, such waves are to be expected from the fact that glacier flow continues throughout the year, whereas the ablation (loss of ice from the glacier surface) occurs only in summer. Using a simple theory in which it is assumed that the velocity is constant throughout the year and that the ablation occurs suddenly once a year, he showed how such waves could be predicted from velocity and ablation data. He then applied this theory to the ice fall on Austerdalsbreen (a Norwegian glacier), for which measurements of these quantities are available, and found that the location of the crests and troughs agrees well with the predictions, and the order of their amplitude is right, though they are, in fact, less marked than the theory predicts —a result that is to be expected if the assumptions made in the theory are relaxed in a reasonable way.

Among others who discussed glacier theory, Prof. M. Matchinski (France) emphasized the importance of obtaining glacier theories which could be used to describe any glacier of complex shape, and proposed a theory to do this containing parameters to be determined from the glacier itself, and Prof. D. Tonini (Italy) suggested the use of the concept of the characteristic time of a glacier to describe the rate with which the outflow of material on a glacier responds to a change in its accumulation.

Measurements of ice movement on glaciers were naturally also discussed, and here one of the most interesting contributions came from Prof. R. G. Millecamps and M. M. Lafargue (Paris). They have sunk a large number of barium titanate ultrasonic transmitter/receiver units into the ice at the corners of a rectangular lattice, and have used measurements of the time taken for signals to travel between the different units for determining the strain suffered by the ice. At present, only preliminary results are available, and these seem to be curiously irregular; however, the technique is clearly one that holds out great promise, since it enables the full deformation of the ice through the depth of the glacier to be measured. A second technique of great importance was reported by Profs. R. P. Sharp and S. Epstein (California Institute of Technology). They have used the variations in the ratio of the isotopes oxygen-18 and oxygen-16 to determine the history of different parcels of ice. This ratio varies according to the season of the year, and also the altitude of the place in which the snow fell, and they quoted several examples where it had been of value in confirming whether ice samples found to be close to each other in the lower reaches of a glacier in fact came from the same region.

One of the most interesting developments in more orthodox methods of glacier study is the increasing use of photogrammetry, both terrestrial and aerial, to determine not only the map of a glacier, but also the velocity of flow and the variation in surface height of glaciers. For flow measurements, the photographs are usually taken with an interval of several days, and preferably from an identical position, but it was shown that even aerial photographs (which are necessarily not taken from exactly the same position on two different flights) could be used, if necessary, to determine glacier flow. There was some discussion of the best method of analysing such photographs, M. M. Baussart (Paris) favouring the plotting of two maps, one for each date, and deducing the velocity either from these or from the data from which they are constructed, whereas Dr. W. Hofmann (Munich) preferred to use two photographs taken at different times to give the velocity directly. However, it seems clear that both techniques give accurate results, and can even do so when no ground control at all is available. There were also many reports of measurements of glacier flow and variations of the more conventional kind, and perhaps the most interesting of these were some of the first results of International Geophysical Year expeditions to Antarctica given by Dr. L. D. Dolgushin (Moscow) and Dr. J. H. Zumberge (Ann Arbor, Michigan). The former described the features developed by flow in the large outflow glaciers of Queen Mary Land, while the latter reported on the deformation features on the Ross Ice Shelf.

J. W. GLEN

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[1] Nye, J. F., *Nature*, 181, 1450 (1958).

THE HUMAN OPERATOR AND HIGH-SPEED FLIGHT

THE first International Congress of Aeronautical Sciences was held in Madrid, during September 8–13, when representatives from twenty countries met to discuss forty-five papers delivered under the presidency of Dr. Theodore von Kármán.

The subjects included theoretical and applied science dealing with structures, aerodynamics, speed, height, range, propulsion, the handling of supersonic aircraft, navigation, aircraft taking-off and landing vertically, engine noise, and also the important subject of human engineering.

The human element is the limiting factor which faces the designer and operator of the new generation of high-speed aircraft. But considerable information has been accumulated over the past fifteen years about the physical and mental strains on a pilot subjected to violent manœuvres, and also about the psychological factors causing fatigue and thus an involuntary falling-off in efficiency. This experience has come from branches of science outside the general field of aeronautical engineering, namely, in the aero-medical field including physiology, neurophysiology and psychology.

From the early stages of design study for a new aeroplane the problem of the human operator is studied by scientists working with the design team to ensure that human limitations do not prevent the machine being flown to the best advantage.

Military and civil aircraft present some common problems, but naturally those of the combat aeroplane are particularly difficult; pioneering work on military aircraft is frequently useful for the later generations of civil machines, including the now familiar pressure suits worn by air-crews for the protection of the body against physical damage, and radar devices for navigation.

An invariable problem posed by the human operator and his working space in the cockpit lies in variations in size and shape of body, and arm- and leg-reach, all in some way affecting operating comfort and efficiency and involving, for example, the clearance between apparatus, controls, and the canopy. More intangible problems are those concerned with muscle, nerve and brain, underlying the senses and reactions, and much has yet to be discovered.

Laboratories exist in many countries for practical work as well as for theoretical analyses in the study of human engineering, which applies to any task in which physical and mental co-ordination is required of the operator. Too many tasks in the past have been carried out by the human operator adapting himself to the machine, whether it be aeroplane, machine ~~tool,~~ forging machine, or instrument observation.

The aircraft designer is thus increasingly required to range over a varied scientific field, and to consult other specialists on the human operator aspect. The following topics were discussed at the Congress:

(1) Simplification of the work of the air-crew, both physical and mental.

(2) The study of all aspects of visual observation both inside and outside the cockpit, including the design and arrangement of the instruments. Outside the cockpit the angle of view from a pressurized aircraft is limited, and with increase in performance a television display, reliable under all weather conditions, is desirable.

(3) Location, design and shape of controls, levers, and knobs, for instant recognition by sight or touch, day or night.

(4) Reliable information about what fuel remains at any given time, and what aerodromes are available within the remaining range.

(5) Warning lights that are insistent, but not too violent, for vital emergencies, and illuminated descriptive panels for secondary troubles.

(6) Air conditioning and temperature control.

(7) Methods of escape to safety in case of an emergency; the self-contained detachable cockpit dropping by a parachute, after clearing the air wreck, to a suitable altitude from which the crew can escape on their own parachutes.

(8) Disorientation in flight.

(9) Protection against cosmic radiation during space flight.

(10) The problem of weightlessness in space.

Observing, thinking and making a movement takes time whether it concerns operating an aeroplane, a machine tool or playing the piano, but smooth and apparently effortless action by an operator having a mastery of his task shows a high degree of combined skill.

The hazards and increasing complication of flying have encouraged great efforts to be made to reduce the reaction-time of air-crew, between hearing or seeing some signal and acting on it. One action may have to be followed by a second or a third, all taking time depending on how much mental interpretation is required after observing the dials and lights. A good deal of work can be performed quickly by robot-type apparatus ; but it can carry out only what it has been programmed to do, and cannot readily be adapted to differentiate between courses and evaluate alternative action. Robot apparatus, moreover, frequently occupies much space and is weighty, and it needs skilled attention to keep it serviceable.

Extending the pilot's senses without increase in fatigue is an important factor in getting the best out of an aeroplane. Vision is most important : many miles will have been travelled in the few seconds required to stop observing an instrument a few feet away on the cockpit panel, and to sight and recognize a distant aeroplane.

Quick-acting robot apparatus is best used in relieving the pilot of physical tasks ; for presenting the assorted instrument readings as integrated results ; and for displaying a flat television picture of the view around the aeroplane.

While aircraft design and construction has to conform to accepted standards and official specifications, no such definite direction is possible on the more intangible aspects relating to the human operator and so every new experience reported by air-crews is carefully studied, and may be the starting-point for further aero-medical research.

The many instruments on cockpit panels are arranged in groups or in horizontal and vertical rows so that the readings relating to a particular operational function may be viewed together. This helps in the rapid assimilation of facts from which the pilot mentally assesses the conditions. There remain the possible chance of error in observation, and the time-lag before any action follows : to improve matters, apparatus is being developed which will receive the instrumental readings and give the pilot a combined result from which he can take immediate action.

Thus the process of adapting the aeroplane to the lot continues and reduces the chances of accidents e to so-called 'pilot error'. It has been a convention [illegible] attribute many crashes to "an error in judgment [illegible] the part of the pilot" when, in fact, the cause has en due to confusing or difficult operating conditions, hich become more hazardous when the pilot is tigued and flying conditions are bad.

The experience of the past ten years is now being ed in the design study of new manned aircraft, and sks apparently impossible for the pilot are now ing assigned to apparatus with the pilot as the aster mind. For example, an apparatus designed [illegible] relieve the pilot during combat at high speeds is e Ferranti 'Airpass' system (airborne interception dar and pilot's attack sight system). After several ars development it is now fitted in the English ectric *P.* 1*B* high-speed fighter. 'Airpass' starts [illegible] operate when the fighter is beamed in the direction [illegible] a target, it scans ahead and when the target is cated the radar locks on and a computer finds the best course for the aeroplane. The pilot observes the essential facts in his sights and acts at the right time. He has been relieved of the visual strain and the anxiety of determining the correct course and can concentrate on the proper time to fire.

Progress has been helped greatly by the aero-medical pilots who understand test flying and take part in it, co-operating with other specialist scientists in the design team in the study of the operational requirements of a new aircraft, and how these can best be met. A full-scale cockpit model is tested under varying climatic conditions for maximum operational periods. These tests disclose discomforts due to pressure suits, difficulties in making movements to operate controls and switches, and escape facilities. In adapting the future aircraft to the pilot it must be emphasized that operation at supersonic speeds presents conditions of control quite different from those in sub-sonic flight, while kinetic heating demands a cooling system to prevent excessive rises in temperature.

Present-day control columns and rudder pedals will probably give way to a set of small hand levers on the pilot's desk console, which will also have communication aids and signals, the television picture of the outside view being at eye-level beyond the console, and visible to any other members of the air-crew.

The new self-contained type of control cabin can more readily be accommodated within the best aerodynamic shape, avoiding the usual sharp hump in the top curve of the fuselage due to the cabin windscreen and roof. The windscreen spoils good performance at supersonic speeds, and it should not be permitted in the new aircraft using television display. Operation would be entirely by remote control using television and other instruments, but a retractable periscope would be useful for ground manœuvring.

Other fields of human engineering include the operation of cars and lorries, fast Diesel trains, automatic manufacturing plant, and many others co-ordinated by the Ergonomics Research Society and covering international interests.

It would not be realistic to suppose that manned combat aircraft will become obsolete in the near future, and it may be assumed that air-crew will be needed for many military operations, but their task must be made simpler. Unmanned robot aircraft and missiles have a future. But it is unwise to think that these could replace certain attack and defence duties.

The important development of VTOL aircraft (vertical take-off and landing) and STOL aircraft (short take-off and landing) were discussed at the Congress, and it was emphasized that failure-proof apparatus for autostabilization and landing are essential if these types of aircraft are to be successful.

Human engineering applied to helicopters is concerned with control factors quite different from those of the fixed-wing aircraft, but some basic problems are similar. When controlling a helicopter, the pilot is continually using his hands and feet to maintain stability, and at present it is necessary to keep the ground in view, until a reliable automatic pilot system is available to permit safe flying in all weathers.

The special senses reacting to linear and angular movement often prove misleading to a pilot when he is not engaged in steady straight flight, yet these are two of the three main sources of information about orientation which emphasizes the supreme importance of the eyes. Under some conditions of prolonged manœuvre even the eyes may prove misleading for a time during the manœuvre, or immediately after it has been completed. Facts on the limits of human tolerance in aviation and on the question of reaction-times are being accumulated in the leading national institutions, so that more data are available to designers.

Crew for manned space-flights will have to be selected from test pilots trained to retain normal physiological and psychological functions under severe conditions.

Two problems which are particularly difficult to study on the Earth are those of weightlessness, and the effects of cosmic radiation. Weightlessness, which can be studied for short periods under certain conditions of parabolic flight, causes disturbances of muscular co-ordination and the nervous system, leading to awkward functions of certain reflexes. There may also be long-term effects on respiration and disturbance of the alimentary canal. Generally, there is likely to be a reduction of the input of information to the sensory pathways of the brain, and thus some effect on the mental processes. Recent data from *Explorer* satellites and the *Sputnik* 3 reveal a belt of intense radiation between latitude 30° N. and 30° S., at a height of about 6,000 miles and beyond. This may be a serious barrier to manned rockets in this region, but in the equatorial zone there seems to be relatively little radiation, according to the information at present available, so that it may be possible for future manned rockets to avoid this hazard to some extent.

A. Cadman Clinton

HYDROMEDUSAE NEW TO THE BRITISH LIST FROM THE FIRTH OF CLYDE

By C. EDWARDS

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In the course of work on the plankton of the Firth of Clyde a survey of the Hydromedusae has been made from early 1956 to the present date, because of their value as hydrographic and biological 'indicators'[1,2] of conditions in the area. Further, it is thought that they are a valuable guide to the zoogeographical relationships of the Clyde fauna. Finally, this survey may prove of service in the future in the detection of any long-term changes in the fauna.

The Clyde fauna has proved to be rich in number of species of Hydromedusae, forty-seven species having been found during this work. A full report on them will be published on completion of the survey. As, however, the four undermentioned species, new to the British list, have been found, this preliminary note is of value at the present stage.

Plotocnide borealis Wagner. Twelve specimens have been taken in surface tow-nettings at Millport in April and May 1956 and during February-April 1957. None has been found in 1958. Routine daily surface-water temperatures on the dates of capture ranged from 6·1° to 9·0° C. The earlier occurrence of the species in 1957, compared with 1956, reflected the much milder winter and earlier spring of 1957 compared with the previous year. Its apparent absence in 1958 may have been due to the fact that cold winter conditions were unusually prolonged and were followed by an exceptional period of persistent east winds, which delayed the onset of spring conditions and appeared to disfavour certain forms normally occurring in late winter and early spring.

This species has been considered to be an arctic one of circumpolar distribution[3,4], having been reported from western Greenland, the White, Barents and Chuckchee Seas and the Sea of Okhotsk. However, Beyer[5] recorded its occurrence in the Oslofjord between 1946 and 1953, although he suggested the possibility that it may there be an arctic survivor from some cold period, capable of living at the temperature (about 6° C.) of the deeper layers of the Oslofjord.

The survival of *Plotocnide borealis* in the Clyde area as an arctic relict is extremely unlikely. While its accidental introduction into the area in the hydroid stage is possible, it is considered unnecessary to attribute its presence here to that cause. It is a very small medusa, easily overlooked and nowhere reported as abundant, and its apparently disjunct distribution may be due to limitations of collecting. Its occurrence in the Clyde area over at least two years suggests that conditions here are suited to the species. The medusa faunas of the regions from which *Plotocnide borealis* has been reported include a number of other species the ranges of which extend from arctic to boreal regions, such as *Hybocodon prolifer*, *Rathkea octopunctata*, *Staurophora mertensi*, *Tiaropsis multicirrata* and *Aglantha digitale*, all of which occur in the Clyde area. The presence of northern boreal and boreal-arctic forms in arctic seas is well known. For example, Gurjanova[6] has shown, in the case of amphipods, that many Atlantic northern bor species have penetrated into the deeper parts of t Russian arctic seas because of relatively warm wa in the deeper layers of the Arctic basin. It is sign cant that Jaschnov[4] reports that, in the Barents Se *Plotocnide borealis* occurs in the deep layers. T appearance of many boreal species in the waters western Greenland during recent decades, because climatic change, is well known[7]. The presence deep, cool water in the Firth of Clyde may favour t establishment of any cold-water forms entering t area. It is considered that *Plotocnide borealis* can longer be regarded as a purely arctic species, but true distribution must await further discovery. T hydroid stage is unknown.

Bougainvillia muscoides (M. Sars) [*B. nordgaa* (Browne)]. This medusa has hitherto been report only from fjords on the west coast of Norway betwe Bergen and Molde, a single offshore locality nor east of the Shetlands, and one station over the Wyv Thomson Ridge[8]. In addition, the hydroid has be recorded from the west coasts of Sweden and Norwa In Norway the medusae have usually been found fro August to November, and exceptionally in April a May.

The species occurred at Millport in 1956, twenty-one specimens being found between September 18 and October 11. The fact that various stages were taken, ranging from very young ones to adults, indicated that the hydroid was present in the area. This species exemplifies faunal similarities between the west coasts of Scotland and Norway. It is probably present elsewhere along the Scottish west coast, as is suggested by the record from over the Wyville Thomson Ridge.

Bougainvillia macloviana Lesson. This well-known species is widely distributed and abundant in antarctic and subantarctic waters[10]. It has, however, been repeatedly found since 1895, though in limited numbers, in the southeastern part of the North Sea at Heligoland and off the East Frisian Islands, during April, May and June[11,12]. Its occurrence in the North Sea is attributed to transportation of the hydroid on ships from the antarctic.

One adult medusa was taken in the Firth of Clyde on June 14, 1956, and the introduction of the species into this area is similarly explained as due to transportation from the southern hemisphere. Whaling vessels from the Antarctic frequently lie up in the lochs off the Firth.

Tiaranna rotunda (Quoy and Gaimard). This species is recorded from the Straits of Gibraltar and the region immediately to the east, the northern North Sea, fjords in western Norway, the Skagerrak, Davis Strait, the Irminger Sea (between south-west Iceland and south-east Greenland), and the South Atlantic and Antarctic Oceans[3,10,13]. It is a deep-water species only occasionally ascending towards the surface. Russell, in his account of the British medusae[14], included it on the ground that, although not recorded from the British area, it might occur over deep water off our western and northern coasts.

Twelve specimens have been taken off Great Cumbrae Island, Firth of Clyde, two during October and November 1956 and the remainder between July and December 1957. Three were adult, the others very small. The species was evidently resident in the area. With the exception of one adult specimen taken in an oblique haul from 90 metres depth to the surface, all the others were caught in surface townettings. The presence of a considerable body of fairly deep water (attaining 168 m. or more in depth) in the Clyde area has enabled the species to establish itself here.

Of additional interest is the discovery that the young stages, previously unknown, agree very closely with the description and figures of *Modeeria formosa* Forbes[15], based on a single specimen taken off Mull in the autumn of 1845 and not recorded since. It is highly probable that the two species are identical, but, because of the uncertainty of Forbes's specimen, it is advisable not to disturb the well-established name of the species. Descriptions of the young stages will be published in due course.

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NUCLEOTIDE POOL OF BREWERS' YEAST DURING GROWTH AND FERMENTATION

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It is known[1,2] that yeasts contain pools of nucleotides analogous to the reserves of amino-acids[3]. A detailed analysis of the nucleotide pool of bakers' yeast at one stage of growth, made[1] by extracting the organism with cold perchloric acid followed by chromatography of the acid-free extract on 'Dowex'-1 (formate), showed that it contained the mono-, di- and tri-phosphates of adenine, guanine, cytosine and uracil together with various new nucleotides, notably uridine diphosphate glucose (UDPG) and uridine diphosphate acetylglucosamine (UDAAG)[4]. We have now examined the nucleotides present in a brewers' yeast (*Saccharomyces cerevisiae*, National Collection of Yeast Cultures, No. 240) at successive stages of growth and fermentation.

The yeast was grown aerobically for 48 hr. and inoculated into brewers' wort, when it was allowed to grow and ferment without agitation. The methods employed for analysing the cells differed from those used by earlier workers in that extraction was performed in two stages, the first using hot aqueous ethanol for a limited period and the second cold trichloracetic acid. The two extracts from each sample of yeast were individually chromatographed on 'Dowex-1' (chloride), following Pontis and Blumson[5], to give the chromatograms shown in Figs. 1 and 2.

Clearly, the total nucleotides are divided by these means into two main groups. The first contained the compounds previously observed in bakers' yeast together with at least five unidentified nucleotides (1–5), while the second group comprised a large number of new components (7–31, Fig. 2). Full details of the properties of the unidentified materials will be published elsewhere. Figs. 1 and 2 reveal, moreover, remarkable changes in the nucleotide pool as the development of the yeast proceeds. In particular, the nucleotides extracted by trichloracetic acid show a considerable increase both in amount and diversification during the first four hours, that is to say, in that period in which the yeast is preparing to undergo its first division. So far as can be judged from the number of samples examined, this increase

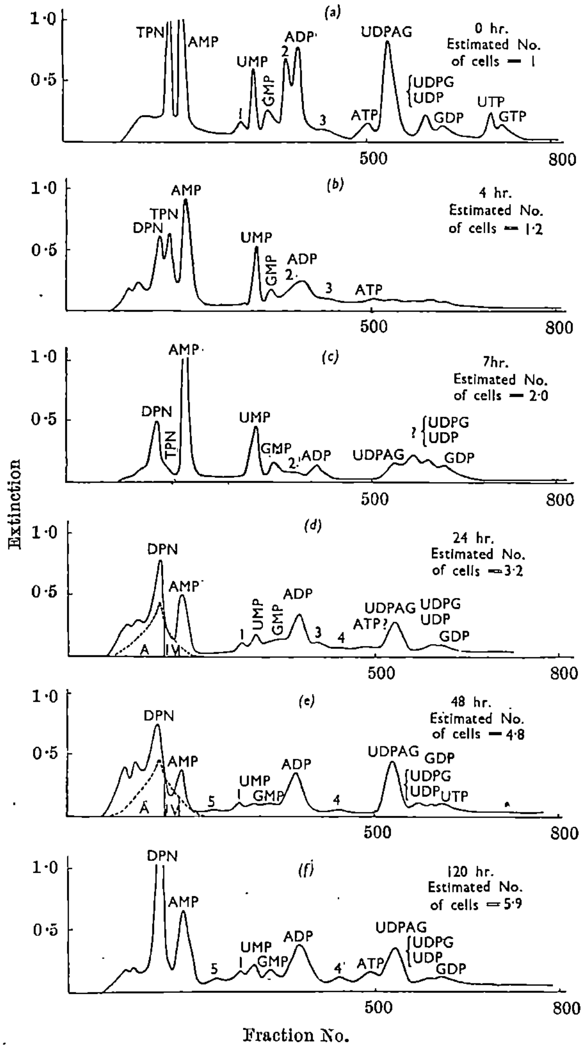

Fig. 1. Key: *A*, adenosine; *G*, guanosine; *U*, uridine; *MP*, *DP*, *TP*, mono-, di-, and tri-phosphate, respectively

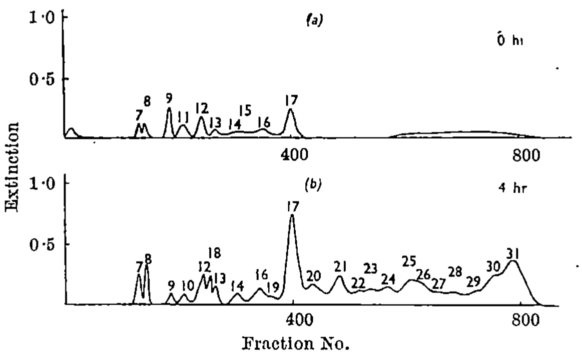

Fig. 2

Figs. 1 and 2. Chromatograms obtained by elution of yeast nucleotides from 'Dowex'-1 (chloride) in a calcium chloride–hydrochloric acid gradient (ref. 5) and determination of the absorption of ultra-violet light in the eluted fractions (each of 10 ml.). Samples of yeast (30 gm.) were removed from the medium after intervals of 0, 4, 7, 24, 48 and 120 hr., and each sample was extracted initially with aqueous ethanol and finally with cold trichloracetic acid. The extracts were chromatographed individually and the substances responsible for the peaks identified tentatively by means of their positions on the chromatogram, behaviour on paper chromatography, and isolation as their calcium salts (ref. 5) and determination of the absorption characteristics for ultra-violet light of the regenerated nucleotides under acid and alkaline conditions

coincides with a fall in the amounts of the nucleotides originally present, a fact which suggests that the nucleotides soluble only in trichloracetic acid are formed at the expense of the compounds soluble in alcohol. That the components soluble in acid appear during the synthesis of nucleic acids further suggests that they are intermediates in this process. In this connexion it is relevant to note that Ogur *et al.*[6] and others[7] have shown, using budding yeast and other organisms under selected conditions, that deoxyribonucleic acid is synthesized before cell division occurs. In addition, the participation of intermediates adsorbed on 'template material' and released only by treatment with acids has been inferred by Miettinen[8] and by Cowie and Bolton[9]. Furthermore, Okazaki and Okazaki[10] demonstrated that certain polymeric deoxyribonucleotides, separable on 'Dowex'-1 (formate), are active growth promoters in the presence of thymidine for a thymidineless strain of *Lactobacillus acidophilus* by virtue of their participation in the synthesis of deoxyribonucleic acid.

The selective extraction of the compounds soluble in acid mentioned above from yeast would appear to offer a means whereby they may be concentrated, separated and investigated structurally. Obviously, their isolation in useful quantity is best attempted at a critical early point in the development of the cell culture as their amounts decline rapidly after active growth sets in, possibly because they undergo rapid turnover during the subsequent life of the culture. In this connexion it would be desirable to study the changes in the nucleotide composition of synchronously budding cells, but adequate techniques for this purpose have still to be devised.

Finally, it has been found in the present work that many of the nucleotides, extracted by either hot or cold ethanol and separated by chromatography on 'Dowex'-1 (chloride), are associated with either peptides or sugars. Indeed, certain peptides at least are chemically bound to the nucleotides as in the case of a number of components located in zone *A* (Fig. 1*d* and *e*). Koningsberger *et al.*[11] have observed the presence of similar nucleotide–peptide complexes in bakers' yeast and, on the basis of the reaction of these substances with hydroxylamine to form hydroxamic acids, have suggested that they are intermediates in protein synthesis. The nucleotides which we have detected also react with hydroxylamine to form hydroxamic acids. While the precise nature of the peptide–nucleotide association remains uncertain (cf. Raacke[12]), it is perhaps significant that the compounds from yeast resemble in respects additional to their reaction with hydroxylamine the amino-acid adenylates containing a phosphoanhydride linkage[13]. For example, as mentioned above, they migrate towards the cathode on electrophoresis and, furthermore, they are eluted from 'Dowex'-1 (chloride) by means of sodium acetate solution at *p*H 5–7 [13]. This latter property makes possible their separation from other nucleotides, particularly tri- and di-phosphopyridine nucleotide (TPN and DPN) and adenosine monophosphate, which cannot be achieved by the procedure of Pontis and Blumson[5]. By employing this improved technique, coupled with chromatography and electrophoresis on paper, concentrates of the nucleotide–peptide compounds have been prepared in purified condition. One such complex, originally occupying section IV of zone *A* (Fig. 1*d* and *e*), unexpectedly proved on purification to have the ultra-violet absorption of the type given by uridine, rather than adenosine, while on hydrolysis it yielded uracil together with a mixture of amino-acids in which arginine, cystine, glutamic acid and leucine predominated. In contrast to the acid-soluble nucleotides discussed above, the nucleotide–peptide compounds are readily obtainable at late stages of the cells' development. Structural investigations both on these compounds and on the above-mentioned intermediates in nucleic acid synthesis are in progress.

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PRESENCE OF A FACTOR INHIBITING BITING IN *AEDES AEGYPTI*

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EVIDENCE has been obtained[1] that mated and unmated females of the Liverpool strain of *Aedes aegypti* (recently identified by Mattingly of the British Museum as *A. aegypti* var. *queenslandensis*) differ markedly in their avidity for blood. Whereas the mated females show a cyclical biting pattern which appears to correspond closely to the gonadotrophic cycle, the unmated females show no such cyclical biting activity, feed at a high level and lay few eggs. Gillett[2], who has studied ovulation in a Newala strain of *A. aegypti* (in which the unmated females, as in the case of the Liverpool strain, lay few eggs), showed that ovulation occurs a few days after mating; the factor responsible for this behaviour was named the ovulation hormone[3].

In the experiments described in this article at least two factors have been shown to be operative in the gonadotrophic-biting cycle. One of these appears to be identical with that previously described as the ovulation hormone[2,3], while the other is a hitherto unrecognized factor designated here as the 'biting-inhibitory factor'.

As in the earlier studies, the mosquitoes used were *A. aegypti* var. *queenslandensis*, the conditions under which the experiments were conducted being similar to those previously described[1]. Unmated females from a single 'pupal crop' were maintained on sugar water for four days and on the fifth day were offered a blood meal on a human volunteer. All the insects which had taken a full blood meal were then separated off into groups in cages, each group being offered a blood meal again on the sixth and seventh day. On the eighth day of the experiment, when the oocytes had reached the fifth stage, approximately three times the number of recently emerged males were introduced into each cage, mating being observed to occur almost immediately. Half an hour later the males were removed from the cages.

The effect of mating on the biting activity of the females was dramatic. Shortly after the removal of the males the arm of the volunteer was inserted for 10 min. into each cage, at intervals over a period of several hours. In all the experiments the percentage of mosquitoes biting fell steadily with time, and, in most cases, before a period of 2 hr. had elapsed, no mosquitoes would feed (Fig. 1).

In a further series of experiments observations were extended to a period covering several days. It was noted in these studies that the females (offered a blood meal for 15 min.) soon recovered from the biting-inhibitory effect produced as a result of mating, and that by the fourth or fifth hour (occasionally longer in some experiments) biting once more rose to a high level although all the females were fertilized

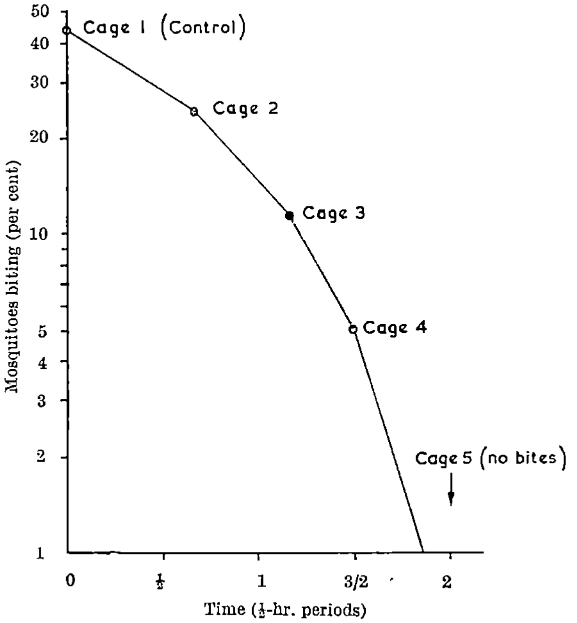

Fig. 1. Graph showing the effect of mating on the biting activity of previously unmated *Aedes aegypti* with fifth-stage oocytes. Each cage contained a group of 50–60 females. Whereas no males had been introduced into cage 1 (the control group), the females in the remaining four cages were mated; all the females were afterwards dissected. The results are plotted on semi-logarithmic co-ordinates

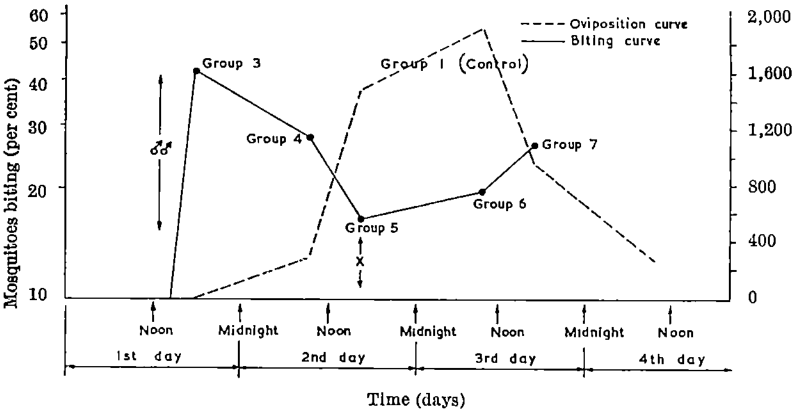

Fig. 2. Graph showing the relationship of the biting curve to the oviposition curve of a population of 520 female *Aedes aegypti* (divided into seven unequal groups) which were mated when the oocytes had reached stage 5. Group 1 (the control; indicated by the broken line) was used for the oviposition curve, while groups 2–7 (joined by the running line) were used for the biting curve, each group being dissected following feeding (group 2 does not appear in the figure because only one bite was registered). The biting curve records only the percentage of females (with fifth-stage oocytes) which fed; not until 5 p.m. on the second day (point *X* on the graph) were the first females found (8 per cent of group 5) which had laid all their eggs. The biting curve is plotted on semi-logarithmic co-ordinates and the oviposition curve on arithmetic co-ordinates

(indicating successful mating), nearly all contained fifth-stage oocytes and no eggs had been laid. As is shown in Fig. 2, the peak of egg-laying activity followed some considerable time after the peak of biting activity.

Although there was some variation in both series of experiments, the same pattern of behaviour was always repeated.

It seems evident from these observations that the biting-inhibitory factor is not the same substance as the ovulation hormone for, if this was the case, ovulation would be expected to follow at, or soon after, the disappearance of the inhibitory effect (4–5 hr. after mating). It therefore appears that in the normal gonadotrophic-biting cycle at least two factors, the production of which is dependent on previous mating, are involved. These two factors operate in harmony in the normal cycle[1], with the result that their individual identity cannot be recognized, but if mating is delayed until the fifth stage of ovarian development it is possible to observe the presence not only of the ovulation hormone[2,3] but also of that of a 'biting-inhibitory factor'.

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MAGNETIC PROPERTIES OF SPIN-FREE TRANSITION SERIES COMPLEXES

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THE magnetic behaviour of the sets of d-electrons which arise for the various transition element ions has received much attention in the literature. It has long been recognized that in the first transition series, where the spin-orbit coupling constants are not large, the magnetic moments which are found are the result of a partial quenching of the orbital angular momentum of the free ion by the ligand fields to which the ion is subject in a co-ordination complex. Frequently, the approximation that the spin-orbit coupling is much less than the thermal energy available for populating excited states is made—that is, $\lambda \ll kT$—so that all the members of the ground-state multiplet are taken to be occupied. (I employ λ, the spin-orbit coupling constant for the free ion spectroscopic term, in order to emphasize the fact that I am dealing with spin-free complexes only.) It may then be expected that the moments involved should lie between $\sqrt{\{4S(S+1)+L(L+1)\}}$ and the spin-only $\sqrt{\{4S(S+1)\}}$, according to the degree to which L, the orbital angular momentum, is quenched[1]. However, since values of λ lie between 50 and 800 cm.$^{-1}$ for the first transition series free ions, and are not much lower in actual complexes[2], and kT at room temperature is about 200 cm.$^{-1}$, it is obvious that such an approximation is unjustified. It is necessary to examine the ground-states of the ions in somewhat more detail in order to obtain a satisfactory account of the moments observed. This has been done in considerable detail for a few cases[3–6] and more generally for some others[7,8]. The purpose of this article is to summarize in a simple and easily utilized form the results available from the literature for the various d^n configurations and to complete the calculations for configurations not so available.

The ligand field to which a transition-element ion is subject in a complex may be classified, for the present purposes, as (1) strong if it is sufficiently large to force the pairing of electron spins; (2) medium if it is large enough to force the electrons to occupy 'private' d_ε and d_γ orbitals, provided they do not have to pair off spins to do so; and (3) weak if the spectroscopic terms of the free ion are maintained, although split into a number of components. A medium ligand field corresponds to the breaking down of the 1–1 coupling part of the Russell-Saunders coupling scheme for the free ion, a strong field to the breaking down of the s–s coupling part as well. For a great many co-ordination compounds the approximation that the ligand field is of entirely cubic symmetry is not unreasonable if it is desired to deal with the average magnetic properties of ions only, as distinct from the magnetic anisotropy. In this article the magnetic properties of all the d^n configurations will be outlined under this assumption for both medium and weak fields. The problem of strong fields under this assumption has been dealt with[7]. In refs. 3 and 4 the magnetic anisotropy was of importance, and here we simplify the results to cubic symmetry. In ref. 8 the expressions for d^6 and d^7 in medium cubic fields are given; we make the simple extension to d^2, d^3, d^4 and d^8. Finally, the results of calculations on the weak field configurations of d^2, d^3, d^7 and d^8 are presented. Most of the information is presented in graphical as well as analytical form to facilitate the appreciation of its significance and its application to the interpretation of the behaviour of magnetic moment with temperature.

Griffith[8] has shown how the matrix elements of spin-orbit coupling and the magnetic moment operator may be obtained for all the medium field configurations $(d_\varepsilon^n d_\gamma^m)$ by analogy with p^n configurations by means of arguments based on group theory. Alternatively, they may be obtained by direct calculation after the manner of Kotani[7], and the results set out in Figs. 1–4 were so obtained. For the D spectroscopic terms which arise for transition element ions there is no difference between the weak field and the medium field approximations. Penney and Schlapp[3] gave matrices for ligand fields of low symmetry for the F terms, which were not susceptible to exact solution in the general case. With the approximation of cubic symmetry, exact solution is possible, and this forms the basis for the weak field results for F terms quoted here.

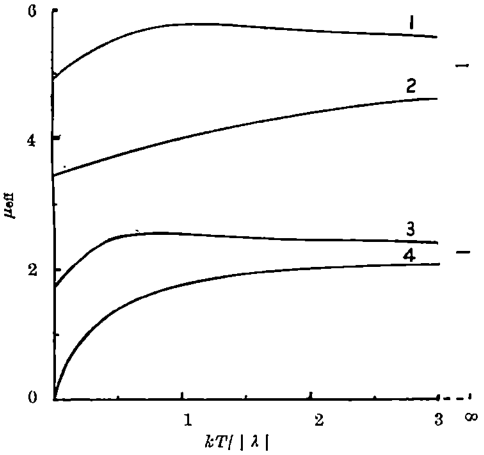

Fig. 1. μ_{eff} versus $kT/|\lambda|$ for ^2D: Ti^{3+} (octahedral, λ positive) and Cu^{2+} (tetrahedral, λ negative),

$$\mu_{\text{eff}}^2 = \frac{8 + (3x - 8)\exp(-3x/2)}{x\{2 + \exp(-3x/2)\}} \text{ with } x = \lambda/kT$$

^5D: Mn^{3+} (tetrahedral, λ positive) and Fe^{2+} (octahedral, λ negative)

$$\mu_{\text{eff}}^2 = \frac{3\{28x + 9{\cdot}333 + (22{\cdot}5x + 4{\cdot}167)\exp(-3x) + (24{\cdot}5x - 13{\cdot}5)\exp(-5x)\}}{x\{7 + 5\exp(-3x) + 3\exp(-5x)\}}$$

(1) ^5D, T_1; $d_\varepsilon^4 d_\gamma^2$, λ negative. (2) ^5D, T_1; $d_\gamma^2 d_\varepsilon^2$, λ positive. (3) ^2D, T_1; $d_\gamma^4 d_\varepsilon^5$, λ negative. (4) ^2D, T_1; d_ε^1, λ positive

There is no difference between weak and medium field cases

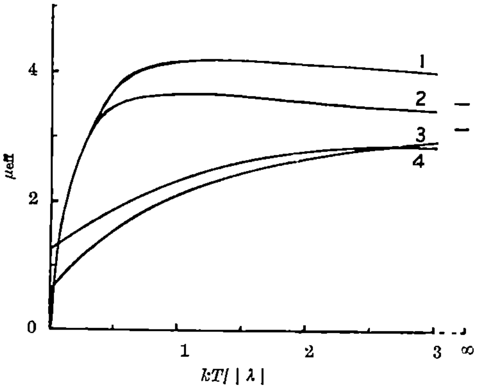

Fig. 2. μ_{eff} versus $kT/|\lambda|$ for V^{3+} (octahedral, λ positive) and Ni^{2+} (tetrahedral, λ negative). (a) weak field (^3F) and (b) medium field (d_ε^2 and $d_\gamma^4 d_\varepsilon^4$)

$$(a)\ \mu_{\text{eff}}^2 = \frac{3\{0{\cdot}625x + 6{\cdot}80 + (0{\cdot}125x + 4{\cdot}09)\exp(-3x) - 10{\cdot}89\exp(-9x/2)\}}{x\{5 + 3\exp(-3x) + \exp(-9x/2)\}}$$

$$(b)\ \mu_{\text{eff}}^2 = \frac{3\{5x + 15 + (x + 9)\exp(-2x) - 24\exp(-3x)\}}{2x\{5 + 3\exp(-2x) + \exp(-3x)\}}.$$

(1) ^3F, T_1; λ negative. (2) $d_\gamma^4 d_\varepsilon^4$, $^3T_1$; λ negative. (3) ^3F, T_1; λ positive. (4) d_ε^2, $^3T_1$; λ positive

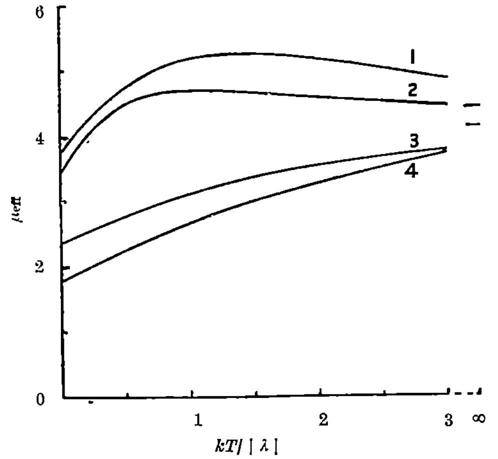

Fig. 3. μ_{eff} versus $kT/|\lambda|$ for Cr^{3+} (tetrahedral, λ positive) and Co^{2+} (octahedral, λ negative). (a) weak field (^4F) and (b) medium field (d_ε^3 and $d_\varepsilon^5 d_\gamma^2$)

$$(a)\ \mu_{\text{eff}}^2 = \frac{3(3{\cdot}15x + 3{\cdot}92 + (2{\cdot}84x + 2{\cdot}13)\exp(-15x/4) + (4{\cdot}7x - 6{\cdot}05)\exp(-6x)\}}{x\{3 + 2\exp(-15x/4) + \exp(-6x)\}}$$

$$(b)\ \mu_{\text{eff}}^2 = \frac{3\{5{\cdot}6x + 4{\cdot}32 + (3{\cdot}6x + 2{\cdot}347)\exp(-5x/2) + (4x - 6{\cdot}667)\exp(-4x)\}}{x\{3 + 2\exp(-5x/2) + \exp(-4x)\}}$$

(1) ^4F, T_1; λ negative. (2) $d_\varepsilon^5 d_\gamma^2$, $^4T_1$; λ negative. (3) $d_\gamma^2 d_\varepsilon$, $^4T_1$; λ positive. (4) ^4F, T_1; λ positive

From Penney and Schlapp it can be shown that the orbital wave functions of the T_1 orbital triplet (which lies lowest or highest according to the configuration and the sign of the ligand field) from an F term in a cubic ligand field are:

$$\psi_1 = \frac{1}{\sqrt{24}}(\sqrt{15}<3| + 3< -1|),\ \psi_2 = <0|,\ \psi_3 = \frac{1}{\sqrt{24}}(\sqrt{15}<-3| + 3<1|),$$

where $<n|$ indicates the d-orbital wave function of the free ion with $M_l = n$. They are combined with spin wave functions corresponding to $S = 3/2$ for ^4F and $S = 1$ for ^3F. It is not possible to assign an effective value to L here, but it can be shown that for $kT/\lambda \rightarrow \infty$, $\mu_{\text{eff}} \rightarrow \sqrt{\{4S(S + 1) + 4{\cdot}5\}}$. For the medium field configurations $(d_\varepsilon^m d_\gamma^n)$ the orbital wave functions corresponding to the weak field ones are:

$$\psi_1 = < -1|,\ \psi_2 = \frac{1}{\sqrt{2}}(<2| - < -2|),\ \psi_3 = <1|,$$

taken with the same spin wave functions. Here the effective value of L, L', is 1 and $\mu_{\text{eff}} \rightarrow \sqrt{\{4S(S + 1) + L'(L' + 1)\}} = \sqrt{\{4S(S + 1) + 2\}}$ as $kT/\lambda \rightarrow \infty$. These latter wave functions also apply to the orbital triplet T_2 resulting from the splitting of a D state by a cubic ligand field; here, spin wave functions corresponding to $S = \frac{1}{2}$ and $S = 2$ are required, respectively, for the ^2D and ^5D terms which arise.

In Fig. 4 the splittings which occur when the orbital triplets form the ground-terms are given by (*a*) the cubic ligand field, (*b*) the spin-orbit coupling, and (*c*) the magnetic field in first approximation. In obtaining the expressions for the susceptibilities it is necessary to consider the magnetic field in second approximation also. In Figs. 1–3 the magnetic moments for the various configurations are plotted as a function of the parameter kT/λ ($= 1/x$).

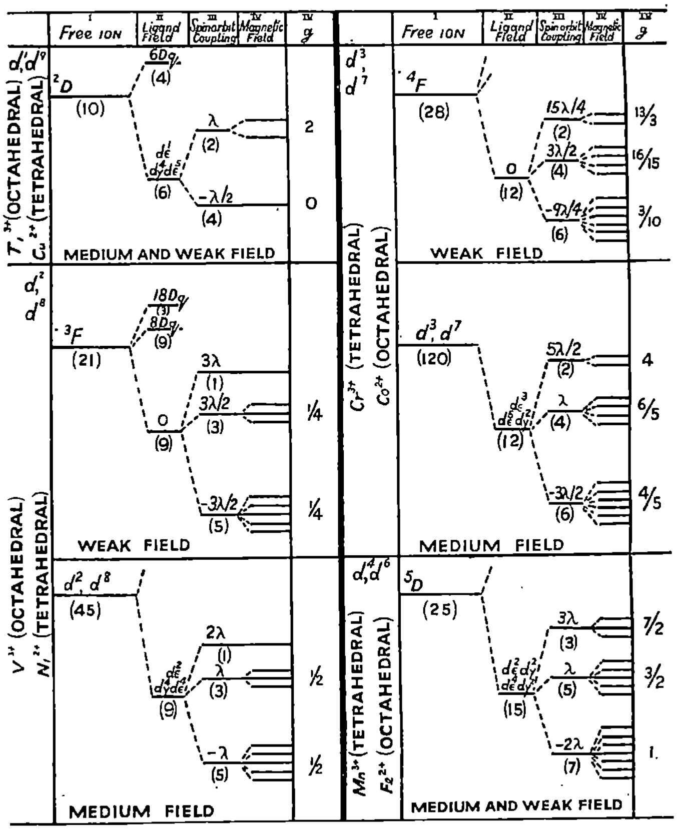
Free ion
Ligand Field
Spin-orbit Coupling
Magnetic Field
g
$d^1 d^9$
T_i^{3+} (OCTAHEDRAL) Cu^{2+} (TETRAHEDRAL)
MEDIUM AND WEAK FIELD
$d^2 d^8$
WEAK FIELD
V^{3+} (OCTAHEDRAL) Ni^{2+} (TETRAHEDRAL)
MEDIUM FIELD
$d^3 d^7$
Cr^{3+} (TETRAHEDRAL) Co^{2+} (OCTAHEDRAL)
$d^4 d^6$
Mn^{3+} (TETRAHEDRAL) Fe^{2+} (OCTAHEDRAL)
MEDIUM AND WEAK FIELD

Fig. 4. Splitting of transition-element ion ground-terms under various approximations

When the orbital triplets do not form the ground-levels, these are an orbital singlet from an *F* term (and its medium field equivalent) and an orbital doublet from the *D* terms. Then, in first approximation, the moment should be the spin-only value. However, in second approximation the spin-orbit coupling, by connecting the orbital wave functions

$$\frac{1}{\sqrt{2}}(<2| - < -2|)(d_{xy}) \text{ and}$$

$$\frac{1}{\sqrt{2}}(<2| + < -2|)(d_{x^2-y^2}),$$

introduces the correction factors:

$$\mu_{\text{eff}} = \mu_{\text{spin-only}}\left(1 - \frac{4\lambda}{10Dq}\right) \text{ for } F$$

terms[3] and medium field equivalent

$$\mu_{\text{eff}} = \mu_{\text{spin-only}}\left(1 - \frac{2\lambda}{10Dq}\right) \text{ for } D \text{ terms}^6.$$

In Table 1 the moments derived from the free ion value of the spin-orbit coupling constant and the moment at room temperature are given under the approximations outlined above, and are compared with experimental moments for the ions concerned and with the spin-only moments and with $\sqrt{\{4S(S+1) + L(L+1)\}}$. It is seen that the fact that the moments mostly lie somewhat above the spin-only value is rather fortuitous, depending in a number of cases on the existence of a favourable value of the ratio kT/λ. When other values of kT/λ are arranged, as by performing magnetic measurements at low temperatures, it is to be expected that moments considerably above or below the spin-only value should be observed for certain ions.

Table 1. MAGNETIC MOMENTS OF FIRST TRANSITION SERIES ELEMENT IONS UNDER VARIOUS APPROXIMATIONS

Ion	Ti^{3+}		V^{3+}		Cr^{3+}		Mn^{3+}		Fe^{2+}		Co^{2+}		Ni^{2+}		Cu^{2+}	
λ (free ion) (cm.$^{-1}$) μ_{eff} (spin-only) $\sqrt{\{4S(S+1)+L(L+1)\}}$	154 1·73 3·00		105 2·83 4·46		87 3·88 5·20		88 4·90 5·47		−100 4·90 5·47		−180 3·88 5·20		−335 2·83 4·46		−852 1·73 3·00	
Stereochemistry*	oct.	tet.	oct.	tet.	oct.	tet.	oct.	tet.	oct.	tet.	oct.	tet.	oct.	tet.	oct.	tet.
μ_{eff} (weak field) (B.m.)	1·9	1·7	2·7	2·8	3·8	3·4	4·85	4·5	5·6	5·0	5·1	4·5	3·4	4·1	1·9	2·2
μ_{eff} (medium field) (B.m.)			2·7			3·7					4·7			3·5		
μ_{eff} (observed) (B.m.)	1·8		2·8		3·8		4·9		5·4†	5·3	5·0†	4·3†	3·2†	3·9	1·9	2·0?

* oct. = octahedral; tet. = tetrahedral. † A range of values is found.

For those ions where the difference between the medium and weak field moments at room temperature is significant the experimental results do not provide definite evidence of the superiority of one approximation over the other. This is anticipated on three counts: (1) the field-strength is likely to be intermediate between weak and medium, (2) the approximation of cubic symmetry is likely to fail in most complexes and (3) except where the ground-level is the 'non-magnetic' orbital singlet or doublet, the effects of spin-orbit coupling in mixing higher ligand field levels into the ground-level has been ignored, as also has the effect of bonding on the magnetic electrons. In this connexion it is necessary to repeat the warning given in ref. 8 against uncritical use of such formulæ; they should provide a valuable general guide to moments of first row transition element ions and their dependence on temperature, but may require much modification in individual cases.

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Supplement to NATURE

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WILLIAM HARVEY AND HIS CRITICS

The Circulation of the Blood

Two Anatomical Essays by William Harvey, together with nine letters written by him. The whole translated from the Latin and slightly annotated by Kenneth J. Franklin. Pp. xxiii + 184. (Oxford: Blackwell Scientific Publications, 1958.) 22*s.* 6*d.*

THE modern mind, trained to accept, at least tentatively, the latest scientific discovery, finds it hard to envisage a time when tradition was more highly regarded than truth. Yet it was so, even in the seventeenth century.

William Harvey, after demonstrating the circulation of the blood by experiments and by lectures for at least twelve years, published in 1628 his "Exercitatio anatomica de motu cordis et sanguinis in animalibus", often described as "the most important medical work ever written". Few believed Harvey's statements, and very few took the trouble to repeat his experiments in order to confirm or refute the new idea of a circulating blood-stream. Their minds were not attuned to the experimental method, of which Harvey was the first great exponent. Steeped in the teaching of Galen and the ancients, they failed to envisage "how such a circulation takes place without causing upset and mixing of the body's humours and destruction of traditional medicine", as Riolan expressed it. Any statement which contradicted the old and accepted views simply could not be true.

Harvey at first maintained a discreet silence and declined to be drawn into argument by his earlier critics. Only after a lapse of twenty-one years did he reply to the criticism of his friend Riolan in the "Two Anatomical Essays" now under consideration.

Jean Riolan, jun., of Paris, had sent Harvey a copy of his work on pathological anatomy, entitled, "Encheiridium anatomicum et pathologicum", which contained his criticism of Harvey's discovery. Unlike some of the earlier critics, Riolan was not abusive or disrespectful. Apparently seeking for a partial acceptance of the new idea which might satisfy the exponents of traditional medicine, Riolan did not wholly deny that the blood circulated, but he affirmed, or rather re-affirmed, the passage of the blood through the interventricular septum, and stated that the mesentery was devoid of any circulation. He produced no experimental evidence in support of his contention, and it is not surprising that this attempt to satisfy both sides really satisfied neither the critics nor the supporters of the new doctrine. Harvey begins his reply to Riolan with a graceful reference to the value of Riolan's book, mentioning his own interest in pathology, as shown in his writing on "medical anatomy", a work which appears to have been lost. He then proceeds to refute Riolan's statements, and to defend his original contention that "there is a circulation everywhere, and not restricted to certain parts". He admits that he has failed to discover the capillaries, but he now states, as he did not in 1628, that the heart does not re-charge the blood with "innate heat" or "vital spirits", adding "Such spirits show a common subterfuge of ignorance". Harvey must have felt how obstinate were his old-fashioned opponents when he wrote, "How hard and difficult it is to teach those who have no experience the things in which they lack such or have no sensible knowledge".

The eight letters which follow the anatomical essays to Riolan, though much shorter, are no less interesting. All were written during the last few years of Harvey's life, and they show his nobility of character and his gift of kindly friendship. To Nardi he wrote in 1653, "I am myself almost an octogenarian, and, although my physical powers are tottering with my body broken, yet with my mind active I give myself up gladly to studies of this sort", and to his Dutch friend, Jan Vlackveld, just before his death in 1657, he confessed himself "ripe in years but also—let me admit—a little weary" and "entitled to ask for an honourable discharge".

Prof. Kenneth Franklin, who embodies the unusual combination of a master of Latin and a professor of physiology (at St. Bartholomew's Hospital, where Harvey himself taught), made a most valuable contribution to the Harveian tercentenary celebrations last year by his translation of "De Motu Cordis" (see *Nature*, 180, 449; 1957). He has now added to his high reputation by giving us, in deft and elegant English, a modern translation of the essays to Riolan and the letters, under the title "De Circulatione Sanguinis", a fitting, and indeed essential, sequel to the earlier work, showing a more mature Harvey whose outlook had been ripened by years of further meditation and experiment.

"De Circulatione Sanguinis", 1649, is by no means a mere postscript to "De Motu Cordis", 1628, and perhaps it is unfortunate that the two books, bound together in what has been hitherto the standard translation by Robert Willis, now appear separately. Even the intelligent student, viewing them casually, might well regard them as the same book, so similar are they in format and title. The two are so intimately interwoven that they surely deserve to share one cover, and it is hoped they may do so in future editions. The Latin text forms the second half of the volume. Paper and printing are admirable, as also are the annotations and bibliography. Two rather rare illustrations show Riolan at work, and Harvey, in his later years, while a lovely coloured frontispiece of Charles, Prince of Wales, by William Dobson, commissioned by King Charles I and presented to Harvey, has been reproduced from the original painting in the Scottish National Portrait Gallery. Prof. Franklin has certainly revealed a new Harvey to the modern reader. His two delightful translations of the greatest of medical classics depict not only the discovery which inaugurated a new era in medicine but also the dawn of the experimental method and the demonstration of its value in the hands of the noble, erudite and intensely human William Harvey.

DOUGLAS GUTHRIE

PERCEPTION AND COMMUNICATION

Perception and Communication

By D. E. Broadbent. Pp. v+338. (London and New York: Pergamon Press, 1958.) 55*s.* net.

BROADBENT has written what is in many ways a most admirable book. Those who are interested in the analysis of human performance in the artificial environments created by technological advance will find in it a valuable and intelligent summary of the various subjects which have been investigated, many at the Medical Research Council Applied Psychology Unit at Cambridge of which Broadbent is the director. However, it would be misleading to suggest that he has given us a mere factual digest. He performs the difficult and unusual task of relating these findings in the applied fields to the problems which have traditionally been regarded as more fundamental, and shows with great skill that applied research does have theoretical importance. The field he covers in this process ranges from the effects of noise on human skill to latent learning in rats. Regarded as a review and a stimulant to thought, the book is first-rate. However, it can also be read as a theoretical contribution to general psychology. Here, Broadbent has many provocative and interesting suggestions. But there are various places where it seems that a more serious intellectual effort might have led the author to theories of greater depth. He tends to treat theories merely as different jargons; and this is what one might conclude from the way he uses them. His use of the terms of information theory, highly precise in their own context, is somewhat loose and without any clear purpose. His own filter theory is rather like the Freudian theory of memory. It accounts only for our failures while our successes continue by the same obliging miracle which has always served. One fears also that logically the filter theory resembles in many ways the explanations of faculty psychology. The abilities or properties of the whole man are explained by postulating entities each of which displays one of those abilities or properties. The statements of such theories are simple translations of the generalization which they are invoked to explain.

The interpretation of the experimental evidence necessarily precedes the framing of theories, as many results are not what they seem. Theorizing, particularly in psychology, is made difficult because the skill and hunches of experimentation are virtually impossible to convey to those who have not had practical experience. It is very easy to get the accent wrong. Animal experimentation is especially hard to evaluate. Though incomparably better than some of the engineers who have attempted to frame theories of animal behaviour, Broadbent's reviews and suggestions in this field are less felicitous than elsewhere. In his chapter on extinction the important problem of latent extinction is left untouched. Whatever the reason for this omission the experimental data in this field invalidate any such approach to learning or extinction as Broadbent's or Uttley's. The question of goal-extinction has been brought into prominence recently by Moltz, who attempts to solve it in Hullian terms.

Nevertheless, the shortcomings on the animal side are not serious for Broadbent's main thesis of filter theory, which must be judged by its usefulness in thinking about human performance. It might therefore be regarded as curious that no time is spent on the clinical material relevant to such subjects as attention or memory. A much firmer case could be made for the relevance of psychopathology rather than of animal psychology to Broadbent's ideas. Indeed, many of his problems are posed in an acute way in clinical psychology and the brilliance of Breuer's speculations concerning their solution has not been surpassed.

But perhaps these criticisms are not entirely fair. Broadbent in the book does concentrate mainly on the fields where he himself has made important contributions (with the exception of animal work). We cannot therefore reproach him too much for not attempting more. Secondly, it is not entirely clear for whom this book is written. The criticisms would apply in their full force if the book was meant to be a technical contribution. But taken as a more popular volume the force of any of the above strictures is largely lost, and we read with interest a scientist of imagination and intelligence writing about the many subjects to which he has made outstanding contributions.

J. A. DEUTSCH

EVOLUTION OF THE HUMAN MIND

Man's Emerging Mind

Man's Progress Through Time—Trees, Ice, Flood, Atoms and the Universe. By Dr. N. J. Berrill. Pp. xii+308. (London: Dennis Dobson, Ltd., 1958.) 21*s.* net.

THE Primates, feeding in the high, evergreen trees of warm, wet lands, could produce young at any season, but only one, or sometimes two, babies could cling to the mother as she climbed. They could make noises and groom themselves or one another without too much fear of the great cats below, ready to pounce. Swinging arms left legs freer for occasional and, eventually, persistent ground-walking, and the growing head and diminishing snout made this easier as the skull came to rest on the backbone—a very important matter as the brain grew towards its weight of 1,300–1,400 gm. The genes for snout-reduction seem rather specially linked with those for forward-looking eyes, and all these changes were such as Nature would select among groundlings. Development of hair is late in pre-natal life, and its competition with brain-development helped to make men's bodies almost hairless, with advantages in increased sensitivity and decreased parasites. The maintenance of hair on the head has proved valuable in protecting the brain from short-wave radiation, which would otherwise penetrate the thin skull of youth. Maintenance of head-hair led to its development as an ornament in women.

The decrease of body-hair helped, and was helped by, brain growth, at first subject to limits set by the birth-process, but, later, with fœtalization of the skull, continuing through an elongating infancy. Berrill hopes that further elongation of infancy, the trailing clouds of glory, as Wordsworth has it, is in store for mankind, and certainly the age of marriage has risen since Tudor times in Western Europe, and this has been a factor in intellectual activity and diversity of views.

The author might have further expanded the idea of skull growth to show that a decrease of ruggedness, and the early fixity accompanying that ruggedness, helps to account for the 'Mediterranean' dolichocephalic race-character as an evolutionary change from hyperdolichocephals, often with strong brows, who linger among Australian aborigines and elsewhere. Too recent for this book is Dr. Oakley's provisional interpretation of finds as tools of Australopithecines; but, if this becomes established, tools contributed to early brain growth. The author follows general opinion in assigning some importance to sexual selection in mankind.

The book's rapid survey of civilizations emphasizes factors of climatic change very suggestively and, of course, tentatively. The southward spread, from a zone stretching between Mersin and Meshed to the lower parts of the twin-rivers, leads on to the rise of Sumer, a prime germ-centre influencing Egypt, India, Crete, Greece and probably China as well. The unity of Nature, including the whole man, is a leading theme of this book, so the author is in the succession from Spinoza and Goethe through such thinkers of our own culture as Lloyd Morgan, Smuts, Whitehead (whom he aptly quotes) and Alexander. All separatist curtains, whether iron or bamboo or brick, or linguistic or dogmatic, are a menace. Language can condition ideas, and pressures stultify inspirations. Freedom of critical thought and research is of prime importance. There are dangers in setting workers to do specified research tasks except in applications of science; science is more than its applications, and increase of understanding is to be sought along all possible paths, converging towards a goal that is always in the future. H. J. FLEURE

HUMAN STERILITY AND FERTILITY

The Reproductive Development of the Female

With Special Reference to the Period of Adolescent Sterility. By Prof. M. F. Ashley Montagu. Pp. xvii+234. (New York: The Julian Press, Inc., 1957.) 5 dollars.

Reproductive Physiology

Comparative Reproductive Physiology of Domestic Animals, Laboratory Animals and Man. By A. V. Nalbandov. (Series of College Texts in Agricultural Science.) Pp. xi+271. (San Francisco, Calif.: W. H. Freeman and Company; London: Bailey Bros. and Swinfen, Ltd., 1958.) 6.75 dollars; 58*s*.

BOTH these books come from the United States, and they both deal with different aspects of the subjects of sterility and fertility. The first is the more highly specialized of the two works. Prof. Ashley Montagu is an anthropologist as well as an anatomist and he has long been interested in a subject which has puzzled a great many anthropologists, namely, why girls who belong to primitive societies which grant a great deal of sexual freedom to their young people very seldom become pregnant. Malinowski directed attention to this fact in his book, "The Sexual Life of Savages" (published in 1929), after his return from living with the Trobriand Islanders. He writes: "It is very remarkable to note that illegitimate children are rare. The girls seem to remain sterile throughout their period of licence, which begins when they are small children and continues until they marry; when they marry they conceive and breed, sometimes quite prolifically. . . . I was able to find roughly a dozen illegitimate children genealogically in the Trobriands, or one percent". The young islanders shared sleeping mats in the communal sleeping hut to which they repaired at night: they knew nothing about contraceptive methods and they did not practise coitus interruptus. Why did the young girls so seldom become pregnant?

This is no longer a puzzle. Prof. Montagu, the author of the book under review, first published the results of his investigations of the subject in 1946 in a volume entitled "Adolescent Sterility". In the present book he adds fresh evidence of the existence, in all races, of a period of post-pubertal sterility. Previously, it was assumed that the establishment of menstruation was an indication that a woman was now able to procreate, but this is now known to be untrue. There is usually an interval of about three years before conception is likely to take place. It is also clear that even after women have passed this interval they are likely to be less fertile than they will become a few years later. There are several possible explanations of this period of relative infertility, the commonest being failure of the monthly ovulation and imperfect nidation of the fertilized ovum.

The human observations on this subject have been supplemented by similar observations on a number of different animals ranging from mice to chimpanzees. It is interesting to know that although exact observations on the adolescent male are more difficult to obtain, there are good reasons for believing that a similar period of sterility exists also in him. Prof. Montagu quotes Kinsey as stating in his report that "unpublished data gathered by the group study of sex behaviour at Indiana University indicate that there may be a period of some years of adolescent sterility in the human male". This idea is likewise supported by Webster and Young's investigation of the fertility of young male rats and guinea pigs.

Dr. A. V. Nalbandov, a lecturer in the agricultural sciences at the University of Illinois, in his book makes a very wide and complete survey of the subjects of fertility and sterility. His observations have been made on animals, but they throw light also on human fertility and sterility, and this makes his book of considerable importance to gynæcologists and medical men generally. In veterinary as in human practice, one of the difficulties which the research worker encounters is that the sterility or infertility problem is usually a multi-dimensional problem. That is to say, it is due generally to the existence of a number of different factors which may act singly but which usually react on each other so as to render breeding impossible. For example, female ewes which suffer from a reduced fertilizability of their ova often display an increased mortality-rate in the developing embryo. The problem to be dealt with is consequently often a highly complicated one.

Artificial insemination is being more widely used by veterinary surgeons, and Nalbandov attributes this partly to an extended use of semen diluters and partly to better facilities for the storage of semen. But there is a great difference in the viability of the sperms of different animals. While human, bull and chicken semen all withstand freezing at −79° C. and prolonged subsequent storage, semen from a stallion cannot be subjected to this treatment. Indeed, stallion semen loses its fertilizing capacity at ordinary temperatures within forty-eight hours of ejaculation. This is unfortunate, for it makes impossible the use of artificial insemination where it would prove most convenient, namely, as a means of avoiding the transport of valuable thoroughbred stallions. Although bull semen can be stored far better than stallion semen, there is reason to believe that "germ cells age and thus become physiologically less vigorous, and that their senility may be one of the main causes of embryonal mortality in both mammals and birds". Dr. Nalbandov stresses the importance of timing matings or insemination in domestic animals and in man "in such a way as to immunize the deleterious effects of the ageing of the ova and sperm cells".

Dr. Nalbandov's aim has been to give as full an account as possible of the "comparative reproductive physiology of domestic animals, laboratory animals and man", and the book he has written is the most complete work on this subject which the reviewer has, as yet, encountered. The various chapters contain many references to articles and books which provide departure points for further reading on these subjects. Both these new books should become standard works on their respective subjects.

KENNETH WALKER

THE ARRHYTHMIAS

Rhythmusstörungen des Herzens

Systematik—Ursache und Klinische Bedeutung—Therapie. Von Prof. Konrad Spang. Mit beiträgen: Die Morphologie des Reizleitungssystemes, ihre Orthologie und Pathologie. Von Prof. W. Doerr. Physiologie der Herzirregularitäten. Von Dr. W. Trautwein. Pp. xvi + 548 und ein Tafelanhang mit 228 Abb. (Stuttgart: Georg Thieme Verlag, 1957.) 148 D.M.

THE length of this book on a relatively circumscribed subject may at first alarm the reader, but he will be quickly reassured when he begins to study it, for it is clearly arranged and the style is lucid.

The author has set himself the task of re-awakening interest in the arrhythmias. After the initial enthusiasm following the appearance of Sir Thomas Lewis's book and that of Wenckebach and Winterberg, interest has lagged, since only a few arrhythmias are really of clinical importance. The author believes them to be often of greater clinical importance than is sometimes recognized to-day, but at the same time admits that in many cases the only reward of laborious study may be a better understanding of the disordered physiology.

To a British reader the collection of illustrative electrocardiograms at the back of the book, divorced from the text, is a drawback, since inclusion of a suitable illustration on the same page as the text makes for clearer exposition. On the other hand, diagrammatic representation of the mechanism of many of the complicated arrhythmias, such as parasystole, is included in the text and the notation of these diagrams could scarcely be improved, explaining at a glance what neither text nor electrocardiogram could convey simply. The diagrams of abnormal spread of conduction through the heart are also very clear and helpful.

The newer theories of the genesis of some of the arrhythmias, such as atrial fibrillation, are fully discussed. Rhythm changes during special cardiac investigations and during operations on the heart under hypothermia are briefly touched on. In addition, the chapters on treatment include more recent methods, such as the cardiac pace-maker and the defibrillator.

This book attempts to wed academic interest in the arrhythmias to fuller understanding of their clinical importance, and in this it largely succeeds.

J. P. D. MOUNSEY

TREATISE OF ZOOLOGY

Traité de Zoologie

Anatomie, Systématique, Biologie. Publié sous la direction de Prof. Pierre-P. Grassé. Tome 13: Agnathes et Poissons—Anatomie, Éthologie, Systématique. Premier Fascicule: Pp. viii + 924. Deuxième Fascicule: Pp. viii + 925–1812. Troisième Fascicule: Pp. vii + 1813 + 2758. (Paris: Masson et Cie., 1958.) Chaque fascicule, broché, 12,000 francs; cartonné, 13,000 francs.

IT is ten years since the first volume (Vol. 11 in the series) of the "Traité de Zoologie" appeared, and now we have to welcome Vol. 13, the ninth to be published, which is devoted to the Agnatha and Pisces. The total number of volumes in the series is to be eighteen, so that approximately half the work has now been published although there may be rather less to come as some of the larger classes have already been dealt with. Zoologists the world over have come to know what to expect and to look forward to new additions to the treatise. The present volume, with its 2,758 pages, is so large that it has been divided into three almost equal fascicles, each as large as an ordinary volume, containing 924, 888 and 946 pages, respectively. As in all previous volumes, this one is generously furnished with illustrations which form an important part of the work.

The last text-figure is numbered Fig. 1889, but this is misleading and there has been some confusion in numbering, for Fig. 219 on p. 419 is followed on p. 434 by Fig. 245, and Fig. 1043 occurs on p. 1453 and again on p. 1471, so that the actual number is 1865. There are six plates in full colour. This, as in former volumes, does not give a fair impression of the wealth of illustrations, for a number of the figures contain several drawings which may even be on separate pages; for example, Fig. 378 occupies the whole of pp. 588 and 589 and nearly all of p. 590, Figs. 81 and 82 take up five complete pages and the best part of two more. These last two figures furnish excellent examples of a combination of line and colour, not common in text-books, but which in these and twenty-five others has been employed with telling effect. The great majority of the figures are line-blocks or half-tone or a combination of the two, and are on the whole very good although a few half-tones, for example, Figs. 720, 849, 1474 would be much improved if the background were cut out and the impressions were deeper. It is a pity that in the main systematic part (Fascicle 3) so many of the attractive illustrations give no indication of the magnification or reduction, nor is the size stated in the text. There is a certain lack of consistency in nomenclature, for example, sometimes *Lepisosteus* is used (deliberately) and sometimes *Lepidosteus*; sometimes *Scylliorhinus* and at others *Scyllium*.

Twenty-two authors, fifteen of them from Paris and each a specialist in his own field, contribute to the volume, thus ensuring an authoritative and up-to-date treatment. It has been customary for the authors to be chosen from French-speaking zoologists, but an exception has been made in the present instance, and the section devoted to the ostracoderms, fossil cyclostomes (pp. 173-425 in Fascicle 1) is by an eminent authority on the group, Prof. E. Stensiö of Stockholm. This is probably the best general account of the ostracoderms available. It is well illustrated and contains, *inter alia*, a number of half-tone reproductions of actual holotypes. The magnification of the illustrations is almost invariably given, thus conveying an idea of size as well as appearance. There is a slip in the footnote on p. 256, where 'Dr. E. J. Whitte' is printed for what should obviously be Dr. E. I. White. The systematic treatment of the class Osteichthyes follows more or less orthodox lines, so that, as the fossil forms are included with the living throughout, the Crossopterygii come at the end. The last subdivision is a new super-order, the Actinistii containing the single order Coelacanthiformes, which has a single living genus *Latimeria*. While there are references to certain structures in *Latimeria chalumnae* (the only living species in the genus) in the general anatomical treatment of the bony fishes, the more extended account of it is to be found on pp. 2553–2597. The story of the discovery by Prof. J. L. B. Smith of this remarkable form is well known to all zoologists. The authors of this section are Prof. J. Millot and M. J. Anthony of the Natural History Museum in Paris, where there are ten well-preserved specimens. Not only is it a survivor of a group considered to have become extinct in the Cretaceous, but also the Crossopterygii occupy a most important systematic position. The coloured illustration on Plate V gives a clear impression of the appearance of the creature. The description covers a considerable amount of ground in a general way and is illustrated with good original photographs. In view of its rarity and great interest it is being thoroughly investigated by a team of workers, and a full account of this creature has only become available very recently.

Ninety pages of index and table of contents complete a volume which is well worthy of a place in a series widely known for its general excellence. It will remain indispensable for a long time.

C. H. O'Donoghue

TRANSPORT ACROSS CELL MEMBRANES

Metabolic Aspects of Transport across Cell Membranes

Edited by Q. R. Murphy. Pp. xxiv + 379 + 11 plates. (Madison, Wisconsin: University of Wisconsin Press, 1957.) 7.50 dollars.

The format, printing and production of illustrations in this volume are excellent, and the subject-matter summarizes a large amount of information concerning active transport in various tissues. Although the production of this volume was delayed, any notable advances made in the intervening time have been usually included in the proofs or as footnotes therein up to the year 1957.

Eleven formal papers were read, with intercurrent discussions with panel members at the symposium reported. It opened with a paper by Dr. E. F. Adolph on "Regulation in Fluid Exchange" with reference to the whole organism. He was followed by Dr. D. C. Darrow on "Some Aspects of Ion Exchange in Clinical Medicine". Dr. H. H. Ussing's communication was on "General Principles and Theories in Membrane Transport" and Dr. M. B. Visscher's on "Transport of Water and Electrolyte across Intestinal Epithelia".

In the section on ionic transfer in muscle and nerve, papers were read by Dr. E. J. Conway on "Membrane Equilibria in Skeletal Muscle and the Active Transport of Sodium"; by Dr. Silvio Weidman on "Transport of Ions across Cardiac Membranes"; and by Dr. A. M. Shanes on "Ionic Transfer in a Vertebrate Nerve". This was followed by a discussion with Drs. Fenn and Gerard, acting as co-chairmen. Dr. Fenn dealt with buffering mechanisms in relation to acidic treatment either of isolated amphibian muscle or after injection into the whole animal with particular reference to potassium, sodium and chloride exchanges. Dr. Wilde gave an account of his elegant 'effluograph' technique, with which the release of potassium in a single beat of the turtle's heart could be measured accurately. He also developed some clinical applications of the Conway theory. Dr. Brink communicated experimental results mainly concerned with the correlation between loss of potassium and uptake of oxygen in frog nerve. Dr. R. Gerard put forward the views of Dr. G. Ling (who was unable to attend the symposium) with respect to the distribution of potassium and sodium ions inside and outside cells. This was answered by Dr. Conway, who had criticized Dr. Ling's views in his paper. This material was sent later to Dr. Ling, who replied, and a final rejoinder was made by Dr. Conway.

In the section on transport across renal epithelium, Dr. R. W. Berliner read a paper on "Some Aspects of Ion Exchange in Electrolyte Transport by the Renal Tubules". Exchanges of potassium, sodium and hydrogen ions were chiefly considered. The view that the carbonic acid system was responsible for urinary acidification was effectively dealt with, and acidification attributed to sodium and hydrogen ion exchanges. This agrees with the 'redox pump' theory, so named by Dr. Conway, which would in turn interpret the occurrence of carbonic anhydrase in the renal nephrons.

Reference was also made to the evidence pointing to the total re-absorption of the glomerular potassium in the proximal convoluted tubules, and its excretion of potassium lower down the nephron. In this context attention may be directed to the recent experiments of Dr. Morel (*Helv. Physiol. et Pharm. Acta*, **3**; 1956) working with radioautographs of kidney slices after injections of labelled potassium, which appear to demonstrate elegantly such potassium exchanges.

A rather long and occasionally lively discussion followed, the panel members being Dr. Pitts (chairman) and Drs. Davies and Berliner. In this, Dr. Davies presented some new evidence with respect to potassium and sodium exchanges in kidney slices. This discussion was followed by another on the transport of organic compounds across renal epithelium, the panel members being Dr. Shideman (chairman) and Drs. Farah and Beyer. Experimental results of much interest were presented and discussed.

In the section on the secretion of gastric hydrochloric acid, Dr. Davies read a paper on "Gastric Hydrochloric Acid Production—the Present Position". Dr. H. W. Davenport read one on "Metabolic Aspects of Gastric Acid Secretion" and Drs. W. S. Rehm and W. H. Dennis presented "A Discussion of Theories of Hydrochloric Acid Formation in the

Light of Electrophysical Findings". A discussion followed, the panel members being Dr. Pitts (chairman) and Drs. Hogben, Davenport, Davies and Rehm.

In the discussion a lively controversy developed between Drs. Davenport and Davies concerning the true ratio of hydrochloric acid secreted to the oxygen uptake concerned therewith. It may be noted that both workers accepted a redox origin for the hydrogen ions, or the redox pump theory, but, whereas Dr. Davenport considered the upper limit of the ratio to be 4·0, Dr. Davies argued for its being greater than 4·0, with a back-feed of electrons. This controversy is dealt with rather fully by Dr. Conway in a paper on "The Redox Pump Theory and Present Evidence" at a symposium held at Saclay, Paris, 1958. From a new approach it was shown, using Davenport's numerous results with *Rana pipiens*, that it could be confidently concluded that in this species the upper limit of the ratio is 4·0, and the evidence for a similar conclusion from Davenport's mouse results is very strong.

The symposium ended with a discussion on the "Correlation of Clinical Problems and Basic Information relating to Membrane Transport". The panel members were Dr. Visscher (chairman) and Drs. Adolph, Elkington, Darrow, Streeten and Ussing. The chief contributions, with experimental results, were made by Drs. Elkington and Streeten.

BIOLOGICAL D-DAYS

The Ecology of Invasions by Animals and Plants

By Charles S. Elton. Pp. 181+50 plates. (London: Methuen and Co., Ltd., 1958.) 30*s*. net.

THIS is rather a deceptive book because at first it might seem little more than a lightly written, easily read and pleasantly produced account of some of the more outstanding consequences of introducing alien plants and animals where they do not belong. All this indeed it is, but it is also something much more because in the course of it Mr. Elton brings to the reader's notice more than one matter of prime biological importance. As he himself says in the preface, he has tried to bring together ideas from three different streams of thought: faunal history, ecology, and conservation, and on each of these he has something valuable to say.

In discussing the first of the three he develops the idea that before the Cretaceous not only were climatic conditions more generalized but also world-geography was more continuous, so that organic groups, as they evolved, more easily became world wide. Then and since, however, sea transgressions increased the isolation of continents so that each tended to develop its own fauna of birds, mammals and other recent groups. It is this continentality in distribution that is being so rapidly broken down by man to-day. Whatever the geophysical merits of this may be (and it is odd that there seems no mention of theories of continental drift) it is a piece of lively thinking and therefore welcome.

As an ecologist the author is chiefly concerned to make the point that the richer in forms and species a natural community is the greater the inherent stability it has and the better able it is to absorb shocks from outside. He rightly mentions tropical rain-forest as a supreme example of this. No doubt most biologists to-day realize, in some measure at least, that Nature is not a chaos of warring factions but a complex and delicate system of balances in which all share and to which all contribute, but this still cannot be too plainly stated and often repeated.

It is in considering conservation that Mr. Elton does his chief service—by putting fairly and squarely one of the really ultimate questions of biology, namely, what is going to happen when man has finally destroyed (as he certainly will, barring impediments) all the natural floras and faunas of the world. To get the right answer before this happens may make all the difference to the human race.

The book has some beautifully clear maps, but it is a pity that Mercator's projection is used for depicting distribution, a purpose for which it is most unsuitable. To take an example, the genus *Rhododendron* (Fig. 48) cannot possibly occupy, in continental North America, an area greater than that of the whole of Africa; nor is the gap between its North European and Asiatic areas equal to the distance from the Cape to Cairo.

RONALD GOOD

VIRUS STRUCTURE AND FUNCTION

Advances in Virus Research

Edited by Kenneth M. Smith and Max A. Lauffer. Vol. 4. Pp. ix+340. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 8 dollars.

THE dissection of viruses into their structural and functional entities has led to many exciting advances in current problems of virology. Although this volume begins with an excellent essay by Andrewes on the more philosophical topic of virus evolution, most of the contributions are concerned with various aspects of the anatomy and enumeration of virus particles and their mode of attachment and penetration into host cells.

The contributions by Hershey and Tolmach summarize much of the recent knowledge on the biochemical, genetic, structural and functional properties of bacterial viruses. Tolmach has admirably reviewed the mechanism of phage binding and the ensuing processes of 'penetration' and 'injection' of the viral deoxyribonucleic acid. This chapter is not specifically devoted to bacteriophages, yet it serves to emphasize how much more is known about their attachment and penetration than is known for animal viruses. One of the fascinating reactions outlined in Tolmach's article is the increased permeability following phage infection and the 'resealing' or reversal of this change in permeability. The favourable position of the virologist working with bacteriophages is further illustrated by the results of Benzer's experiments on genetic fine structure, mentioned in Hershey's review.

When we depart from the experimentally ideal situation where the ratio of particles to infective units is 1 (as with phages), the problems of measuring virus concentrations become more acute. The chapters by Isaacs and Yarwood make it abundantly clear that in inocula of animal and plant viruses, the particle counts greatly exceed the numbers of successful infections. With mechanical transmission of plant viruses, various treatments can increase the efficiency of infection. There seems to have been little attempt to seek an explanation for some of these effects. Indeed, at present there is no obvious explanation why such large numbers of animal and plant viruses are required to initiate an infection. As Isaacs justly points out, blaming the failure to infect on "non-infective" particles or on "insusceptible" cells, falls into "the category of moral rather than scientific judgement". The enormous discrepancy between particle counts and infectivity titrations raises the problems of recognizing 'viruses' in the electron microscope. Pirie's chapter on the "Anatomy of Tobacco Mosaic Virus" will act as a refreshing antidote to those who infer that the size, shape and properties of the tobacco mosaic virus particle can be rigidly defined.

A diversion from the main theme on the structure, surface immunology and penetration of viruses is provided in the excellent chapter on the "Effects of Non-Ionizing radiations on Viruses" which, on the admission of the author, deals with effects on the biological activities of the virus rather than with any alteration of the component protein and nucleic acid parts.

The articles in this volume are presented in a lucid style, and they make good reading. There is, however, rather more duplication of information than one had hoped for. Virologists' addiction to 'the glossary' is amply illustrated in this book. The origin of this practice is difficult to justify as the terms used are those of general science. If a glossary proves indispensable, then I would at least prefer a non-classical presentation so that I should know, beforehand, the meanings of the terms to be used, rather than leave it until it was too late. M. R. J. SALTON

AN INTRODUCTION TO PHYSIOLOGY

Cell Physiology

By Prof. Arthur C. Giese. Pp. xviii + 534. (Philadelphia and London: W. B. Saunders Company, Ltd., 1957.) 70*s*. net.

WHAT is cell physiology? Since every organism is made up of cells, cell physiology could include the whole of physiology. If cell physiology is intended to cover what I would prefer to call the 'general physiology of the cell', it can be limited to those aspects of physiology which are common to all cells, such as water and salt relations, enzyme action in general, respiration, and, of course, the physical and chemical properties of protoplasm on which these processes depend. Prof. A. C. Giese, in his introductory chapter, makes it clear that what he calls cell physiology is of wider scope than this, for he says that the cellular physiologist is interested in nutrition, response to environment, growth and reproduction.

This would not seem to leave a great deal, but actually most of the book does deal with the general physiology of the cell, including the properties of protoplasm, cell division, cell membranes and the passage of water and dissolved substances through them, enzyme action and respiration. However, in line with Prof. Giese's wider conception of cell physiology, in a section devoted to nutrition, there is a chapter on photosynthesis which, although fundamental for nearly all life, is not to be regarded as within the scope of general physiology, since it is a function limited to the chlorophyll-containing cell. Again, a whole section of five chapters is concerned with irritability and response. Thus the title of Prof. Giese's book seems to me to be a little misleading; a title such as "An Introduction to General Physiology" might, perhaps, have given a better idea of its contents. Indeed, according to the preface, this is what it is intended to be, for we are told that the book is based on a set of lectures given at Stanford University and that logical sequels to the course are "classes in plant physiology, comparative animal physiology, mammalian physiology and bacterial physiology".

As an introduction to physiology the book undoubtedly fulfils its purpose. Physical and physico-chemical principles necessary for an understanding of physiological processes are dealt with adequately, and in this connexion the chapters on acidity and *p*H, and on temperature and life, may be particularly noted. As regards the discussions on the various aspects of cell physiology, I can call to mind no other book designed for students beginning to study physiology which gives such an up-to-date account of these. The book is clearly written and should be of value to the students for whom it is intended.

The illustrations are clear and adequate and many are original, but why is the picture of Brownian movement on p. 10 attributed to Steel's "Physical Chemistry and Biophysics" of 1928? This figure appeared in the late Sir William Bayliss's "Principles of General Physiology" published in 1915, where it was attributed to Perrin, whose original paper was published in 1909. W. STILES

TEA

Tea

By Dr. T. Eden. (Tropical Agriculture Series.) Pp. xvi + 201 + 73 Photographs. (London: Longmans Green and Co., Ltd., 1958.) 35*s*. net.

IT is not known when tea drinking commenced but it was a custom of China even before the Christian era. The Japanese took up tea drinking from the Chinese, and Arab traders brought a knowledge of it to the West. Jesuit missionaries brought a further knowledge of it to the West in the sixteenth and seventeenth centuries. The first arrival of commercial tea in London was between 1650 and 1655. Coffee drinking and the first English coffee houses date from about the same time. To-day the estimated consumption of tea in the United Kingdom is about 10 lb. per person per annum, while that of coffee is about 2 lb. A notable trend in recent years has been the great increase in tea drinking by some countries, especially by the local populations in many parts of the Indian subcontinent and Africa.

As up-to-date books on coffee (by Haarer) and cocoa (by Urquhart) have recently been written, it is fitting that one on tea should now appear. The author is familiar with tea production in many lands and has had a wide experience with the crop, first with the Tea Research Institute of Ceylon and later as the director of the Tea Research Institute of East Africa. All aspects of tea cultivation and preparation are dealt with by the author, and the fundamental agricultural and technological principles of the industry discussed. Much of the information presented is new or the result of recent research, particularly in such sections as those dealing with pests and diseases, manuring and vegetative propagation. The book is well written and well illustrated, and should prove of value wherever tea is grown, and as a reference work. Altogether a very great deal of information has been compressed into a comparatively small space. F. N. HOWES

ENZYME KINETICS

The Chemical Kinetics of Enzyme Action

By Prof. Keith J. Laidler. Pp. vii+419. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 60*s*. net.

ENZYMOLOGY lies between the fields of physical and biological chemistry. Consequently, there is the need for a book to acquaint scientists from each discipline who are interested in enzymes with the basic principles of the other. In his preface, Prof. Laidler states that "this book has been prepared with the idea that it might be helpful to collect together some of the main results and concepts that have developed on the physical side". Because of this emphasis this book is, in the opinion of the reviewer, more suitable for the biochemist wishing to learn about the application of physico-chemical methods to the problem of enzymes than it is to a physical chemist interested in enzymology.

In the first chapter there is an elementary and limited introduction to enzymes for the physical scientist, and this is supported by some of the material of the final chapter concerning protein denaturation. Providing the reader does not expect to learn much about the biochemistry of enzymes from it, the book fulfils its purpose well.

The author is well known for his contribution to chemical kinetics, and in this volume he presents a clear and skilful account of this subject. The treatment is thorough, beginning with a sound introduction to kinetic principles followed by their application to very many interactions between enzyme, substrate and inhibitors. One topic which has been overlooked is a reaction between enzyme and substrate which occurs in more than two kinetically distinguishable steps.

It is regrettable that there is no standard nomenclature in the literature for the description of enzyme-catalysed reactions. Although the treatment in this book is generally consistent there are, unfortunately, a few examples of enzyme reactions for which individual algebraic analysis is required. The reciprocal of the Michaelis constant is used. This is advantageous in that it provides a direct measure of the affinity of enzyme for substrate; but it is unlikely that this change will be popular with many enzymologists. There are a small number of errors in the kinetic expressions, generally due to confusion between rate constants—for example, k_{-1} is sometimes written for k'_{-1}.

Forty-six pages are devoted to the important effect of hydrogen ion concentration on enzymatic activity. The theory is well illustrated by recent examples from the literature, though one might have chosen examples which have given kinetic data of greater precision. Such speculation makes interesting reading, but may, of course, be subject to revision in the light of new work.

The outstanding questions of enzyme action, efficiency and specificity receive brief but stimulating mention. Then follows a review of methods, kinetic and otherwise, which have been of assistance in elucidating enzymic reaction mechanisms.

The author devotes four chapters (110 pages) to a small number of the enzymes which have been subjected to most study, and reviews knowledge about them derived from kinetic and other evidence. The hydrolytic enzymes are treated in some detail; unfortunately, some of the tabulated data (for example, Tables 22 and 35) are not the best available Many values given are now known to be in error The oxidative enzymes and catalase and peroxidase receive brief mention. This review of current work is a difficult task in such a rapidly developing field, and it has not been assisted by the long time-lapse (two years) which appears to have occurred between completion of the manuscript and publication. This is partly compensated by including an appendix of references, some for 1958. Unfortunately, most topics can receive only a curt statement in this.

The emphasis in this volume has been placed on kinetic principles rather than individual enzyme systems, so that most chapters will not become too rapidly out of date. The book can be warmly recommended to biochemists; it is less suitable for physical chemists and others working in the field, although they, too, may find it useful to have as a reference book to specialized kinetic treatments necessary for enzyme reactions. B. R. HAMMOND

INSECTICIDES

Die Insektizide

Chemie, Wirkungsweise und Toxizität. Von Dr. Werner Perkow. Pp. viii+384. (Heidelberg: Dr. Alfred Hüthig Verlag, 1956.) 28 D.M.

THE author suggests that more research is needed at present on modern insecticides. He asks if enough is really done on a matter the results and progress of which are so essential to the basis of our food supply. Fundamental research work on insecticides is almost non-existent; but it could be decisive for the future efficiency of the pest control mechanism. The book is not a handbook in its strict sense, but the attempt to compile a German compendium on modern insecticides. Its disposition is somewhat uneven. For example, there are chapters named "Phenothiazin . . . " alternating with such titles as "Acarizide".

The chief stress in the contents is on chemical constitution, industrial manufacture, historical development and analytical methods. These subjects are discussed in a substantial form, the author himself being very familiar with them as an industrial chemist. The methods of application are described from the point of view of the insecticides, that is, the chapter on a specific insecticide tends to describe the manner in which this insecticide may be applied. On the other hand, the brevity of the book compared with the enormous extent of the whole subject leads to the result that the matter dealt with is limited: the book cannot be complete inasmuch as some minor subjects are omitted. For example, the reviewer missed calcium arsenite as well as the application to warm-blooded animals of systemic insecticides. But this fact is no vital fault of such an introduction; seen as such, the book is quite comprehensive in the subjects discussed.

However, in a very few cases the formulations of the text are not very convincing; for example, such a sentence as "Stored food protection is no simple problem and needs knowledge of the matter as well as responsibility" could have been applied similarly to other insecticidal matters. The chapter on bioassay methods is sufficiently comprehensive for an introduction, while the chapter on insecticide application by aircraft is too short for an English reader. It is a good idea of the author's to go into the subjects of toxicology and biology. Concerning these chapters, it must be borne in mind that the author himself is neither biologist nor toxicologist. Thus some minor points regarding such matters do not show an exactitude comparable to that displayed in his own subject. But the author can be applauded for commending the plant insecticides, since they are less toxic than the synthetic ones. They are especially worthy of recommendation for the control of insects of medical importance or other insects living in inhabited buildings. Considering the shortness of some other chapters, that on historical development is somewhat long. The subject index at the end of the book is very comprehensive and undoubtedly useful.

WD. EICHLER

A SCIENTIFIC ANALYSIS OF FIXATION AND DYEING

Principles of Biological Microtechnique

A Study of Fixation and Dyeing. By Dr. John R. Baker. Pp. 357. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1958.) 45*s*. net.

WHEN the reviewer began learning the basic techniques of cytology and histology, it was believed that fixing and staining were more an art than a science: with the same material, the same fixative and the same stain, very different results were obtained by good and bad cytologists. For some reason, still mysterious, Unna's methyl green-pyronine always stains nucleic acids properly in Brussels and refuses to do so in many experienced laboratories elsewhere. It is the great merit of Dr. John Baker, who has been deeply impressed by the great work of Ehrlich—to whose memory the book is dedicated—that he has shown that fixing and dyeing are based on sound scientific knowledge: his book contains no practical instructions on how to make a microscopical preparation, but emphasizes "the principle that when we make a microscopical preparation of any sort, we ought to try to understand what we are doing, for otherwise we shall examine an unknown object that has been treated in an unknown way".

Dr. Baker's book is divided into two main parts: fixation and dyeing. In the first chapter, which is an introduction to fixation, the author emphasizes the differences between a fixative and a preservative, a coagulant and a non-coagulant fixative; he then discusses the question of artefacts. The next chapter deals with the visible effects of the reaction of fixatives with proteins (precipitation, flocculation, single clot formation, gel formation, etc.). The chemical changes produced in these reactions are the subject of Chapter 3: coagulants (sublimate, chromium tetroxide, potassium dichromate, acetic acid) are examined in this respect, and the differences between additive and non-additive fixatives are stressed.

In Chapter 4, Dr. Baker examines the reaction of fixatives with tissues and cells, partly on the basis of model experiments made on gelatine - albumin mixtures. Shrinkage and swelling during fixing and embedding in various media are discussed. In Chapters 5 and 6, coagulants (ethanol, picric acid, mercuric chloride, chromium trioxide) and non-coagulants (formaldehyde, osmium tetroxide, potassium dichromate, acetic acid) are considered individually from many points of view (standard concentration for fixation, description, ionization, redox potential, manufacture, introduction as fixative, reactions with proteins, lipids and carbohydrates, rate of penetration, shrinkage or swelling, effects on cell constituents, on dyeing and on the histological picture). Finally, in Chapter 7, twenty-five aqueous and two non-aqueous fixative mixtures are described and discussed.

Chapter 8, an introduction to the chemical composition of dyes, opens Part 2: chromophores and auxochromes are discussed, and pararosaniline, basic fuchsine, leucobases, basic and acid dyes serve as examples. Dyes are classified in Chapter 9 according to their chemical composition, while Chapter 10 deals with the more complex problem of the direct attachment of dyes to tissues: the role of the electric charges on the dye ions and on the objects dyed is especially stressed; the basophil or acidophil character of cellular constituents, apparent isoelectric point of the cell, the effects of washing with water or alcohol, the nature of the fixative mixtures used, etc., are examined in great detail. The subject of the next chapter is, by contrast, the indirect attachment of dyes to tissues (use of mordants, formation of lakes, differentiation, mechanism of Gram staining).

In Chapter 12, Dr. Baker discusses the differential action of dyes: depth of coloration is affected by chemical affinity, density and permeability; nucleic acids and collagen are chosen as the main examples. Metachromasy is examined in the next chapter, the emphasis being placed on Lison's theory. Blood dyes (Ehrlich, Romanowsky, Giemsa) are discussed in Chapter 14, while the two next chapters deal with vital dyes. Finally, dyeing is compared with other processes of colouring in the last chapter: substances which dye cell constituents by dissolving in them are called 'lysochromes' (for example, sudan III in the case of lipids); the principles of silvering and the use of fluorochromes are briefly presented.

The book ends with an appendix, in which the author presents a number of model experiments on fixation and dyeing, as well as a few notes on spelling: for example, he insists on the use of basiphil rather than the usual terms basophil or basophilic. Dr. Baker is probably right there, but he is almost certainly fighting a losing battle: scientists, as a rule, do not care enough about grammatical correctness and etymology to give up words which are in general use and understood by all.

The book is well written and well presented; the many German and French quotations (the latter not always perfectly correct) and the historical approach remind us of the fact that Dr. Baker is a true scholar. There is no doubt that his book will be useful to all those who want to understand what they are doing when they handle cells or tissues with 'classical' histological techniques.

J. BRACHET

MASS SPECTROSCOPY

Nuclear Masses and their Determination

Proceedings of the Conference held in the Max-Planck-Institut für Chemie, Mainz, 10–12 July, 1956. Edited by Prof. H. Hintenberger. Pp. ix+267. (London and New York: Pergamon Press, 1957.) 84*s*. net.

THE conference, the proceedings of which are recorded in this book, was held to mark the sixtieth birthday of Prof. J. Mattauch, of the Max Planck Institute. He has himself contributed much to the growth of mass spectroscopy, which during his life-time has become one of the most precise fields of physics, relative masses being determined in some cases to a few parts in 10^8. This accuracy and the wide number of techniques which are employed make the subject a testing-ground for the methods of several branches of physics. It is in such a situation that a conference can be the greatest stimulus to research, and the proceedings form a current review of the subject in all its aspects.

Since the previous conference on mass spectroscopy in 1951 much of the disagreement between mass values obtained by mass spectroscopes and by nuclear Q-value measurements has been resolved; however, there is still a significant disagreement in some cases, and much of the discussion concerned the possible sources of disparity.

The book opens with an authoritative review of the situation by K. T. Bainbridge, with a good list of references. This is followed by a short account of empirical mass formulae by A. H. Wapstra, and a study of the effects of shell structure on binding energies by U. Cappeller, mainly by a collection of graphs. A paper on the regularities appearing when beta-decay disintegration energies are plotted against neutron number was presented by K. Way, but without theoretical interpretation, and indeed this aspect was sadly lacking at the conference.

The next session comprised the latest mass spectroscopic results, with an excellent account by A. O. Nier on the work at Minneapolis. H. E. Duckworth described some recent determinations at McMaster University. It was unfortunate that L. G. Smith was unable to attend the conference to describe the synchrometer; a table of results was, however, included.

In the following session the measurements of nuclear masses obtained from nuclear reactions were outlined by W. W. Buechner and the techniques described by D. M. van Patter. It was apparent that results from the new large mass spectroscopes under construction will be matched in precision by accurate reaction measurements, over an expanding range of mass numbers. Results extending to titanium-45 were tabulated by P. M. Endt. In the region of heavier elements the method of determining mass differences by the total disintegration energies from beta- and gamma-decay schemes was described by A. C. G. Mitchell; considerably greater accuracy is attainable in suitable cases than by mass spectroscopic means.

The most stimulating session concerned the comparison between nuclear mass-values obtained from Q-values and from mass-spectroscopic doublets, and two very good contributions were given by J. Mattauch and D. M. van Patter. The sources of remaining discrepancies were closely examined, and the need revealed for further doublet measurements to bring the tabulated mass values to a uniform precision. The dependency of the reaction measurements on the calibration standards (such as polonium alpha-particles) requires a careful check to be made, while the work at the Massachusetts Institute of Technology must be augmented and confirmed by other laboratories.

Microwave spectrum measurements were reviewed by S. Geschwind in the following session. Very small amounts of material are necessary for this method, but the difficulty of preparing molecules of suitable symmetry and volatility is considerable and was not fully discussed.

The remaining third of the book is devoted to descriptions of instruments by the leading authorities: Nier (Minnesota), Ewald (Munich), Ogata (Osaka), Bainbridge (Harvard), Duckworth (McMaster), Hintenberger (Mainz) and Goudsmit (Brookhaven). An interesting idea for an electrostatic time-of-flight spectrometer was outlined by M. J. Higatsberger. This section is liberally illustrated with photographs.

The proceedings closed with three short contributions on standards for mass greater than 30 (H. E. Duckworth), the adjustment of mass spectrographs (F. Everling), and the precision of spectral line measurements (A. H. Wapstra).

The book as a whole is very clearly set out, with full lists of references for each paper, while the systematic arrangement of the contents almost makes up for the lack of an index. A summing-up of the proceedings by the editor would have made a valuable addition. With such an array of authors we have in this volume a very rounded account of the experimental side of the subject at the date of the conference. The list reveals, too, how Great Britain, after the brilliant work of Thomson and Aston, abandoned the field to the rest of the world. It is disappointing that no theoretical interpretation was presented of the many regularities and patterns revealed by the considerable precision now available. A method which shows so directly many features of nuclear forces, and can demonstrate so clearly in the packing-fraction curve the energy release by fission and fusion should, one feels, be worthy of more attention.

G. DEARNALEY

THE GRAVITATIONAL FIELD OF THE EARTH

The Earth and Its Gravity Field

By W. A. Heiskanen and Prof. F. A. Vening Meinesz. (McGraw-Hill Series in the Geological Sciences). Pp. x+470. (London: McGraw-Hill Publishing Company, Ltd., 1958.) 97*s*.

THERE is no modern book on the Earth's gravitational field and much of the literature is somewhat inaccessible and confusing; the publication of this book by the two foremost authorities on the subject is therefore most welcome. Throughout they take a broad view and relate the gravity data to the results of other branches of geophysics and to theories of the origin and development of the earth.

The book opens with an account of current views on the interior of the Earth. This is followed by a detailed discussion of the formal theory of the field of an almost spherical body, including terms of the second order of smallness. Nothing very original can be said on this topic, but the discussion is thorough and gives considerable numerical detail. It should be of permanent value as a critical and readable summary of the matter.

Chapter 4 discusses the instruments used for measuring gravity. Most types of pendulum apparatus and gravimeters are mentioned, but the descriptions are somewhat superficial. It would have been interesting, for example, to know how the creep of gravimeter springs has been reduced to the point where it is possible to measure gravity tides with an accuracy of one part in 10^9. A fuller description of the Meinesz pendulum apparatus for use in a submarine would also have been welcome, since the original and only detailed account has become a rare book. A clear diagram is given of the complex system of fused quartz springs employed in the Worden gravimeter, including the arrangements by which the effects of variations in temperature are eliminated. The inventor of the instrument has for many years returned evasive answers to inquiries about this temperature compensation and it is pleasant at last to be told, at any rate in outline, how he achieves his remarkable results.

The next three chapters deal with isostasy. The methods of reducing gravity observations are described in some detail, and much numerical information is given about the degree of compensation found in various parts of the world. There has in the past been much controversy about the reality and generality of isostatic compensation. This controversy seems now to have subsided, and it is clear that the major features of the Earth's crust, the ocean basins, the fold mountains and the great plateaux are, taken as a whole, quite closely compensated, but that there are other features, such as the island arcs and the rift valleys that are not.

The last chapters discuss the causes of these deviations from hydrostatic equilibrium. This discussion is much more speculative than the rest of the book and is concerned with the downbuckling of geosynclines and island arcs and with the hypothesis that the driving forces are due to a system of convection currents. It is always difficult to produce conclusive evidence for or against a major geological theory, and it is perhaps unlikely that the theories of orogenesis, convection currents and polar wandering set out in this book will be generally adopted in the near future. It is, however, of great value to have a systematic account of their views by two authors who have done so much both to provide the data and to understand its meaning.

E. C. Bullard

MECHANICAL VIBRATION

Engineering Vibrations with Applications to Structures and Machinery

By Prof. Lydik S. Jacobsen and Prof. Robert S. Ayre. (McGraw-Hill Series in Mechanical Engineering.) Pp. xii+564. (London: McGraw-Hill Publishing Company, Ltd., 1958.) 77*s*. 6*d*.

THE suppression and control of mechanical vibration have assumed great importance in engineering. One consequence of this is that the number of text-books on the subject is becoming quite large. But, so far as recent books are concerned, this one is unusual in that its authors have something fresh to say and the ability to say it clearly, simply and accurately. The book is meant to be an introductory one for engineers and, as such, it can be measured against the best. In its general layout the book follows the traditional pattern; the reader is led from the analysis of systems having one degree of freedom to systems with two-, then n-degrees of freedom and finally infinite freedom. Within this all-too-familiar framework, however, the book has some important features of its own.

There are two parts. The first of these deals with systems having one degree of freedom and, right from the start, an unusual degree of emphasis is placed on transient oscillation (in addition to steady-state and free vibration). The treatment of this topic is based mainly on phase-plane constructions and it is as lucid and technically entertaining as it is thorough.

A treatment of energy methods is given in this first part of the book, the single degree of freedom corresponding to motion in a single prescribed mode. It contains an elementary account, not only of Rayleigh's principle, but also of the Dunkerley and Southwell variants of it. It is unfortunate that the fundamentals have here to be dealt with in a rather superficial manner. This is more or less dictated by the academic level of the book, and the authors have therefore chosen to buttress the theoretical treatment with several examples. These are quite well chosen though some are rather complicated for the purposes of introduction. A better result might have been obtained by consigning some of the material to the place where it belongs—in the second part of the book.

The chapter on non-linear vibration is unusually readable. This is largely a result of the fact that the authors do not attempt too much. They firmly limit their treatment to two techniques, namely, graphical methods in the phase plane to cover transient and limit-cycle phenomena and the Ritz–Galerkin method for other steady vibration. The combination is shown to be quite satisfactory for the purposes of this book.

It is the reviewer's belief that writers on non-linear vibration seldom pay proper respect to the linear theory of dynamical instability (a subject which is not dealt with to any extent in this book). Thus, on p. 276 there is the statement that " . . . in a study of self-excited vibrations the non-linearities of the terms in the differential equations describing the motions are of paramount importance and . . . a neglect of them is inadmissible". This comment is partially redeemed in the summary of this chapter, but it is a little misleading since it implies that linear analysis is of no value where self-excitation occurs. This is, however, a minor point since the chapter in question is a first-class piece of writing. If the authors could be persuaded to dispel some of the hocus-pocus from other techniques of analysis in the same way, they would place non-linear vibration theory in a better position than it now occupies.

Part 2 of the book relates to linear multi-freedom systems, and the treatment is fairly simple. The authors do not use the Lagrangian equations, there is no discussion of damping, non-linearity is not introduced and emphasis is no longer placed on transient vibration (principal co-ordinates are not mentioned). Even so it cannot be said that this second part of the book is just a mass of familiar theory. For one thing some unusual topics are introduced—for example, the motions of buildings and the vibration of short beams—and for another the theoretical treatment of some topics is unusual. Thus the vibration of a conservative system with n degrees of freedom is the object of a rather unusual form of analysis.

Every chapter has a summary and a set of excellent examples. Many of the latter have answers given. There are also long lists of references which, so far as the reviewer can see, are mostly (though not always) well chosen from the enormous literature on vibration.

Perhaps the best way to describe this book is to say that it serves the same general purposes and can decently be placed on the same shelf as those of Den Hartog and Timoshenko. In other words, this book must be taken seriously. It has a less practical flavour than the former and has, rather, the more mathematical bias of the latter. But it does not duplicate Timoshenko's book by any means.

R. E. D. Bishop

GEOPHYSICAL VOLUMES OF THE HANDBUCH DER PHYSIK

Handbuch der Physik

Herausgegeben von S. Flügge. Band 47 : Geophysik I. Pp. viii+659. 118 D.M. Band 48 : Geophysik II. Pp. viii+1045. 198 D.M. (Berlin : Springer Verlag, 1956 und 1957.)

THE new "Handbuch der Physik" will contain three volumes on geophysics, of which these two are the only ones so far published. Vol. 47 deals with the solid Earth, and Vol. 48 mainly with the atmosphere and oceans. Both volumes consist of a series of separate essays which between them cover most aspects of the physics of the Earth. Vol. 47 contains sixteen articles, and Vol. 48 seventeen ; nearly all are in English and a few in French or German.

Vol. 47 opens with an article by Spencer Jones on the rotation of the Earth. This is largely concerned with the fluctuations in the rate of rotation, the nature of which has become much clearer in recent years owing to the improved time-keeping possible with quartz oscillators and atomic clocks.

Seismology is treated in a group of six papers by J. Coulomb, K. E. Bullen, W. M. Ewing, F. Press and H. Baule. Much of the material is familiar, but the article by Ewing and Press on surface and guided waves gives much new data on a branch of the subject that is advancing rapidly and has been unjustly neglected in the past.

Gravity and isostasy are discussed by G. D. Garland, the structure of the crust by W. M. Ewing, the forces in the crust by A. E. Scheidegger, and the figure of the Earth by K. Jung. Scheidegger's discussion demonstrates how far from solution the major problems of geology still are. In spite of our greatly increased knowledge of what has to be explained, we are still entirely uncertain of the nature of the forces that mould the crust into mountains, island arcs and plateaux.

The longest article in this volume is that by J. T. Wilson, R. D. Russell and R. M. Farquhar on radioactivity and the age of minerals. This is a valuable review of a subject that has not been treated elsewhere in such detail. The use of radioactive methods of age determination should give a new precision and definiteness to the correlation of pre-Cambrian rocks, and a review by three authors who have done so much to make geological sense of the results is most welcome.

The remaining articles are by J. A. Jacobs on the interior of the Earth, by L. Caignard on electric currents in the Earth, and by S. K. Runcorn on the magnetization of rocks and the magnetism of the Earth's body.

Vol. 48 opens with a 154-page article by A. Eliassen and E. Kleinschmidt on dynamic meteorology. Most of this is devoted to general theory and to the properties and formation of vortices. The general circulation and the jet streams are dealt with only briefly.

There are four articles on radiation in the atmosphere, by F. Möller, W. K. Middleton, Z. Sekera and J. Bricard. The space given to this subject seems excessive in relation to the rather brief treatment of some important parts of the dynamical article. The related question of ozone in the atmosphere is treated by H. Paetzold and E. Regener. Other meteorological articles are on sound propagation in air by E. F. Cox, atmospheric electricity by R. Mühleisen, and the physics of clouds by F. H. Ludlam and B. J. Mason. The latter contains a striking photograph of the production of a towering cumulus cloud by seeding.

An article on meteors by A. C. B. Lovell gives a great deal of information that will be new to most readers, including a discussion of data on upper atmospheric winds derived from the motion of meteor trails.

The section on the oceans opens with a general review by H. V. Sverdrup and an article on waves by H. U. Roll. These are followed by four articles on tides. J. Bartels discusses and tabulates the tide-generating forces, and A. Defant, W. Kertz and R. Tomaschek discuss the tides of the oceans, the atmosphere and the solid Earth. Tomaschek's article contains information that is not otherwise easily accessible.

The book ends with an article by S. Sakuma and T. Nagata on physical volcanology. This is concerned mainly with the distortions of the Earth and magnetic changes associated with volcanic eruptions.

Clearly a very great effort has gone into the production of these volumes, and care has been taken to obtain a complete coverage of the subject. The result is a valuable reference work and a convenient means of learning about many matters in which there is widespread interest. Unfortunately the price is so high that few will be able to own the books, and Vol. 47 is so heavy (4½ lb.) as to be unreadable except at a table. E. C. Bullard

PROBLEMS OF HIGH-SPEED FLIGHT

Aerodynamic Components of Aircraft at High Speeds

Edited by A. F. Donovan and H. R. Lawrence. (High Speed Aerodynamics and Jet Propulsion, Vol. 7.) Pp. xiv+845. (Princeton, N.J. : Princeton University Press ; London : Oxford University Press, 1957.) 120*s.* net.

THIS book is Vol. 7 of an important series of twelve volumes which is planned to give a comprehensive account of the problems of high-speed flight. Some of the volumes have already been issued, and of these Vol. 6, on the "General Theory of High Speed Aerodynamics", is of particular interest as the present volume is closely related to it. Whereas Vol. 6 treats the subject of high-speed aerodynamics in a fundamental and general way, the volume under review deals with specific problems such as the determination of the aerodynamic characteristics of particular parts of the aircraft and the interaction of one part on another.

The book is arranged in seven sections, and in the first, Section *A*, R. T. Jones and Doris Cohen of the Ames Aeronautical Laboratory discuss the basic assumptions of wing theory and their validity. The results obtained by the application of various theories to the calculation of air load distributions at subsonic and supersonic speeds are compared and differences analysed. The material is conveniently presented in three chapters ; the first deals with fundamental considerations such as the use of sweepback in the development of wings for high-speed flight, and the second and third consider the prediction of lift and drag characteristics of the wings of various planforms at subsonic and supersonic speeds, respectively. The whole section runs to about 240 pages and gives a comprehensive account of the subject. It would have made an excellent monograph on lifting surface theory if it had been published separately.

Section *B*, by Clinton E. Brown, of Langley Aeronautical Laboratory, deals with the problem of determining the drag, lift, and pitching moment of bodies, and concludes with a short discussion of stability derivatives for bodies of revolution. This section could and should have been more comprehensive; the latest reference cited was published in 1951. Consequently, many important developments of recent years are not discussed, and this chapter can only be regarded as a brief introduction to the subject.

The treatment of interaction problems by C. Ferrari, Politecnico di Torino, in Section *C* is, on the other hand, much more thorough and particular problems are considered in detail. Attention is mainly concentrated on the interference effect the wing has on the tailplane in subsonic and supersonic flow and the mutual interference of wing-fuselage combinations. A chapter of this section is also devoted to the treatment of propeller interference, including the influence of the propeller on the wing, the propeller and propeller-wing combination on the tailplane and the wing on the propeller. The whole section is well illustrated by diagrams giving comparisons between theory and experiment and extends to 270 pages. It ends with a long list of references, but none published later than 1954.

Section *D*, by C. B. Smith, of Pratt and Witney Aircraft Division, is concerned with the aerodynamic design of high-speed propellers, which are assumed to have thin blade sections and to operate at supersonic velocities. The problems are briefly outlined, and on the basis of two-dimensional strip theory the effect of blade section, planform taper and thickness distribution on the performance of the propeller are investigated. Diagrams to illustrate the effects of varying these parameters are given but no experimental results are included for comparison. The author ends his chapter with some brief remarks on practical structural considerations which must also be taken into account in the design of an efficient and reliable propeller.

In Section *E*, J. C. Evvard, of the Lewis Flight Propulsion Laboratory, briefly considers the problems of diffuser and nozzle design. The one-dimensional equations of flow are given in Chapter 1 and are used for describing the general characteristics of diffusion processes on the assumption that marked effects of laminar or turbulent flow separation are absent. It is emphasized that the real problem of subsonic diffuser design is to accomplish diffusion without separation. Methods of predicting laminar and turbulent separations are briefly discussed. Supersonic diffusion processes are considered at length, particular attention being paid to unsteady flow, 'buzz', in supersonic inlets and various causes of loss of pressure recovery. Some of the problems of exit nozzles and jets are briefly outlined in Chapter 2, such as thrust estimation of exit nozzles, the spreading characteristics of jets and the interactions of jets and after-bodies.

Non-steady wing characteristics are fully discussed by I. E. Garrick, of the Langley Aeronautical Laboratory, in Section *F*. He gives an excellent account of the state of knowledge of this subject up to about 1954. The basic theory is treated in some detail, and the exact solutions that have been obtained for two-dimensional flow are outlined. Transient flows are considered and growth of lift functions for subsonic and supersonic flows are given. Various approximate methods of calculating the load distributions on three-dimensional wings are briefly described and discussed. This section is entirely theoretical except for some concluding remarks on experimental methods for determining aerodynamic coefficients for oscillatory motion. A very long list of useful references to relevant theoretical and experimental work is included.

Finally, Section *G*, by C. W. Frick, of the Ames Aeronautical Laboratory, treats "The Experimental Aerodynamics of Wings at Transonic and Supersonic Speeds". This is a most interesting chapter as it compares theory with experiment and discusses the causes of discrepancies, where they exist. An attempt is made to assess the extent to which various theories can be used with confidence to predict air loads on wings at subsonic, transonic and supersonic speeds.

Progress in aeronautics is so rapid nowadays that any book of this kind unless it is printed very quickly is likely to be out of date in some respects when it is issued. The present volume gives the state of knowledge up to about 1954; but, although this is the case, it contains so much valuable information relating to the design of high-speed aircraft that it should be read with interest by all concerned with such work and by aerodynamicists generally.

W. P. Jones

COMPUTERS GALORE

Notes on Analog–Digital Conversion Techniques

Edited by Alfred K. Susskind. (Technology Press Books in Science and Engineering.) Pp. x+415. (Cambridge, Mass.: Technology Press of the Massachusetts Institute of Technology; New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 80*s*. net.

Computability and Unsolvability

By Prof. Martin Davis. (McGraw-Hill Series in Information Processing and Computers.) Pp. xxv+210. (London: McGraw-Hill Publishing Company, Ltd., 1958.) 58*s*.

Mathematics and Logic for Digital Devices

By Dr. James T. Culbertson. Pp. x+224. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 36*s*.

Logic Machines and Diagrams

By Martin Gardner. Pp. ix+157. (London: McGraw-Hill Publishing Company, Ltd., 1958.) 39*s*.

Electronic Digital Computers

Their Use in Science and Engineering. By Franz L. Alt. (Applied Mathematics and Mechanics, Vol. 4.) Pp. x+336. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 10 dollars.

Reading in Linear Programming

By Dr. S. Vajda. Pp. vii+99. (London: Sir Isaac Pitman and Sons, Ltd., 1958.) 20*s*. net.

NOT only are computers themselves becoming so commonplace that more than 1,000 are in operation in the United States alone, but also the literature in the field, once so scant as to prove embarrassing to teachers and students of the art, is turning from a trickle into a deluge.

The present volumes are a fair example of the way in which publishers are attempting to meet the current interest, and they represent between them both analogue and digital computers, their design and their use.

To consider first the analogue field. The book edited by Susskind is devoted to a very small but increasingly important branch of the art: conversion between analogue and digital representations. There are some good things in the volume, particularly the sections on codes and coding and on optical devices, but the book is long for its content and savours too much of the lecture notes from which it was constructed. It is surely not too much to expect proper pagination and an index in a book of this price.

Davis's book is an attempt to explain, in self-contained and simple terms, the theory of computability pioneered by the late A. M. Turing. It is by no means an easy book to read; but the difficulty is inherent in the theory, and the author has done well to make the subject as readable as he has. Applied mathematicians and programmers will be surprised, if they read as far, to find how complex and unintelligible a simple iterative process can become when handled by a pure mathematician and invested with the mysterious cloak of symbolic logic.

The book by Culbertson might well serve as an introduction to Davis's account. It contains some elementary topics such as notational concepts for sums and products, permutations and combinations, probability and number systems. Most of the book, however, is concerned with developing the elementary notions of symbolic logic and particularly of Boolean algebra as applied to switching circuits. The author writes very clearly, and his simple treatment of the synthesis of a reliable switch from unreliable components will come as a relief to those who have attempted to read the late John von Neumann's essay on the same subject. The author provides numerous examples for the reader and cannot blame the reviewer for summing up the book in the words of the author himself when he illustrates an ambiguous sentence (p. 103): "I cannot recommend this book too highly".

On a less-exalted intellectual plane is Martin Gardner's book on logic machines. The author is noted in the United States as a writer on popular scientific topics, and he has succeeded in putting together a fascinating account of the history of these machines. The writing is clear and the illustrations well chosen and interesting. It seems likely, as the author remarks, that digital computers will replace special purpose logical machines, so that this book may well be the definitive epitaph to this subject. The reviewer has only one regret, which is that there are not more details of the mechanisms of the machines.

It is more difficult to give an opinion on Alt's book as the author himself is uncertain as to its purpose, claiming in one place that it is intended as an introduction to the design and operation of computers and in another that it is a book about computer specialists. In fact, the contents suggest a superficial tour through machines and applications rather than a solid account of either. It is very improbable that readers will gain much knowledge of the structure of computers and their components from the first section of the book, which relies exclusively on words and has no illustrative diagrams. In the same way, the section on problem analysis, although it covers a very wide range, proceeds in so highly condensed a manner that it would not be intelligible to a reader who was unacquainted with the topics discussed. The best part of the book is the last section, on computing laboratory organization, where the author's experience makes a valuable and authoritative account.

Last, but by no means least, is the little book by Vajda. This is concerned with problems the solution of which would only be possible, in the large, on a computing machine. The author's previous book dealt with the mathematical basis of linear programming and the present one formulates the systems of equations associated with a wide range of real industrial and sociological problems. Very little mathematical knowledge is required to understand the problems and their solution, and the book will be invaluable as a guide to industrialists and others who want to know how linear programming can be applied in their day-to-day work. It is perhaps unfortunate that the book has not quite the humorous qualities of William's "Compleat Strategyst" but humour in serious scientific books is a matter of taste, and readers may not share the reviewer's enthusiasm for it.

A. D. BOOTH

IMPROPRIETIES RESOLVED

Introduction to Fourier Analysis and Generalised Functions

By Prof. M. J. Lighthill. (Cambridge Monographs on Mechanics and Applied Mathematics.) Pp. viii + 79. (Cambridge: At the University Press, 1958.) 17*s*. 6*d*. net.

IMPROPER functions, such as Dirac's δ-function which is zero everywhere save at the origin but has a non-zero integral over the range $(-\infty, \infty)$, have in the past been used in mathematical physics with much success and some coyness. Schwartz's theory of distributions, the origins of which may possibly lie in Volterra's pioneering work on functionals, has, according to Temple, "replaced the picturesque magic . . . by a self-consistent technique".

Generalized functions are defined as classes of equivalent sequences of ordinary functions, a process not unlike Cantor's mode of defining irrationals by classes of sequences of rationals. A calculus of generalized functions can be constructed without much technical difficulty, derivatives can be defined in a natural way (though products cannot be), and one great advantage is that there is much freedom in interchanging the order of limiting processes. This, as one might expect, simplifies the appropriate Fourier theory: delicate problems on uniqueness and convergence, the delight of the pure mathematician, disappear from a theory in which term-by-term differentiation and unique determination of the coefficients are practically trivial matters. The theory of Fourier transforms is correspondingly simplified, and follows very naturally upon the definition of generalized functions; picturesquely, the Fourier transform of a periodic function is a row of δ-functions. It seems certain that mathematical physics can profit considerably from this new machinery—that the flexibility and directness of symbolic methods can now be exploited more confidently since their account at the bank of mathematical rigour is no longer 'in the red'.

Lighthill's monograph displays in seventy pages the general setting, the theory of generalized functions, of Fourier transforms and Fourier series, with a particularly interesting chapter on the asymptotic estimation of Fourier transforms. The analysis is surprisingly simple, and should be easily intelligible to a reader with a good knowledge of the integral calculus and some small acquaintance with complex variable theory; the Lebesgue integral is not required. But the basic concept of a generalized function, which will be a novelty to many readers, must be thoroughly understood; the novice will do well to read and re-read the second chapter with great care, and he should not take even the simplest of the few exercises for granted. The good honours degree student with an interest in applied mathematics could readily master the book and derive great profit from his mastery. The exposition is concise, lucid and convincing. The dedication reads: "To Paul Dirac, who saw that it must be true, Laurent Schwartz, who proved it, and George Temple, who showed how simple it could be made". To this admirable summary we may add that Lighthill has made a good book of it. T. A. A. BROADBENT

MORLEY COLLEGE

Offspring of the Vic

A History of Morley College. By Denis Richards. Pp. xix+316+7 plates. (London: Routledge and Kegan Paul, Ltd., 1958.) 18*s*. net.

COFFEE and literature seem indissolubly linked—"It helpeth digestion and procureth alacrity", wrote Burton in his "Anatomy of Melancholy"—and from that time to the present-day *Partisan* in Soho, coffee houses have been the penny universities (as Aytoun Ellis described them in his book two years ago) and the clubs that served as therapeutic centres for the intelligentsia. Yet one more illustration of this indissoluble connexion has been provided for us all by Denis Richards.

The Coffee Music Halls Company was itself a blend of Arnoldian idealism (represented by Thomas Hughes and Dean Stanley, both old Rugbeians) and Ruskinism (represented by Emma Cons). Its one and only venture opened its doors on Boxing Day, 1880, in the former Royal Victoria Theatre, re-christened the Royal Victoria Coffee Hall for the purpose. Ballad concerts and lantern lectures lubricated with copious cups of coffee would, it was hoped, redeem the near-bordello character of the area. Purified variety and teetotal surroundings, however, could not keep the venture going, and so Emma Cons obtained the help of *Nature*. Through its columns she appealed to scientists to help her. This was in 1882, and by October 26 in that year she was able to tell readers that every Friday night more than 600 listeners attended lectures by W. L. Carpenter, Norman Lockyer and other scientific men of the day. "Stamps and whistles of impatience" greeted those lecturers whose apparatus broke down.

Rescued a second time by Samual Morley, a hosiery millionaire, and by the enthusiasm for polytechnics, it became Morley College on September 29, 1889. From then until the present day it has been one of the leading adult education colleges of Great Britain. It moved from the Victoria Theatre to 61 Westminster Bridge Road in December 1924, and during the 1930's, under Eva Hubback, most of the distinguished men and women of the decade came to talk. Music was its especial forte. On October 15, 1940, its second lease of life was ended when a 1,000 kgm. high-explosive bomb shattered 61 Westminster Bridge like a pack of cards, and since the Second World War one of its major battles has been to obtain a new building which, thanks to powerful friends, has been successful. The present warden, Mr. Denis Richards, tells the story with grace and insight and his re-creation of the gallant figures who have helped to build Morley College must be welcomed. It is an admirable prelude to the opening of the new buildings by the Queen Mother this autumn, and it will be welcomed by a wide cross-section of the reading public. W. H. G. ARMYTAGE

SECONDARY MODERN SCHOOLS IN BRITAIN

Secondary Modern Schools

An Interim Report. By Prof. H. C. Dent. Pp. xvi+207. (London: Routledge and Kegan Paul, Ltd., 1958.) 15*s*. net.

THIS is an exhilarating book by an assiduous, experienced, shrewd and sympathetic observer of the educational scene. Prof. H. C. Dent surveys the progress in Britain of what is generically called the secondary modern school since its birth, or rather baptism, in 1945, notes with examples the diversity of its evolving variations, reduces the bewildering diversity to the semblance of a pattern, and speculates upon the shape of things to come.

In the course of his description and appraisal of what is, he suggests, implicitly and explicitly, what might be if modern schools were disposed and able to give a general education "not focused primarily on the traditional subjects of the curriculum, but developing out of the interests of children" ("The New Secondary Schools"). This is the theory, indeed it might be called the philosophy, of the modern school conceived as a type. But as Prof. Dent makes abundantly clear, there are all sorts of reasons—pedagogical, psychological and social—why such a school has not emerged as the general type. It offers only one of the many acceptable curricular patterns for schools which are destined to educate so great a diversity of pupils and so large a proportion of the secondary school population.

This interim report on secondary modern schools is an admirable, lucid and just presentation of the schools that are forcing upon us a fundamental reconsideration of the secondary system. We shall not all agree with Prof. Dent's avowedly tentative speculation that the present secondary modern schools will eventually fall into two types: the 'special courses' and 'general certificate of education' schools on one hand, and the 'arts and crafts', 'projects' and 'interest-orientated' schools on the other. But we shall study with attention and respect his reasons for this prognostication.

In my view he attaches more importance than it warrants to the comparatively recent notion of a tripartite division of secondary education, against which the actual developments he so ably describes are in effect a protest. The developments that are going forward in the schools under review should lead us to discard the term 'modern' along with the rest of an outmoded and self-contradictory theory of secondary education. It serves only to confuse the issue and create factitious problems.

When an educationist of Prof. Dent's reputation foresees the emergence of further types of school, the weight of his authority may do something to bring it about. It is to be hoped that he is wrong, since even if the infinite variety of pupils could be fitted into type schools with single-track aims, all 'types' of school could not be made available everywhere to all 'types' of pupil. Rather should we look to the possibility, within a broad conception of education at the secondary stage, of increasing variety within the schools. Instead of multiplying 'types', let us concentrate upon enlarging the capacity and resources of all schools to fit their curricula and methods to the needs of their pupils and thus enable them the better to do their job.

For an eminently readable account of the job the secondary modern schools are actually doing, their difficulties, frustrations and triumphs, we are all indebted to Prof. Dent. H. Raymond King

FUNDAMENTALS OF SYMBOLIC FORM

The Philosophy of Symbolic Forms

By Ernst Cassirer. Vol. 1 : Language. Pp. xiv+328. (1953.) 40*s*. net. Vol. 2 : Mythical Thought. Pp. xviii+269. (1955.) 40*s*. net. Vol. 3 : The Phenomenology of Knowledge. Pp. xvii+501. 68*s*. net. All translated by Ralph Manheim. (New Haven, Conn. : Yale University Press ; London : Oxford University Press, 1957.)

If an attempt is to be made to review what is, in effect, the essence of Ernst Cassirer's life and thought the only way is to treat these three volumes together, notwithstanding the fact that they have emerged from the Yale University Press at various times during the past five years. The translator has done adequately (and Cassirer could be extraordinarily subtle at times), while the historical and interpretative introductions enable Prof. Hendel to act as a welcome guide. The author was probably the last great thinker who could range over almost the whole field of human endeavour, and illumine it at every level. For it was nothing less that was required of anyone who set out to show not only the content but also the significance of symbolic form, whether in language, mythical thought or the phenomenology of knowledge. As specialization spreads more and more over the whole complex of man's activities (with the power that it brings to discovery and invention), so less and less likely does it become that a fair estimate can be made of the degree of mental adjustment which has been taking place in our awareness of those ultimate verities which can only be expressed symbolically. One has but to recollect the rapid advance in mathematics which followed the introduction of rational and consistent notations to see how potent a factor 'form' is : and not only visual form, but mental form, too, as it tends to crystallize out in clarity of exposition.

Vol. 1 (on language) is based upon the phenomenology of linguistic form and discusses the problem of language in the history of philosophy, then as a phase of sensuous and intuitive expression. After this comes the relation of language to conceptual thought, while the sphere of judgment is treated in the last chapter. Throughout Cassirer's work runs the thread of Kant's influence (and of the Neo-Kantian school at Marburg), strong at all times, but especially so when the "Critique of Judgment" is regarded as the interpretation of an epoch. Thus, three problems presented themselves as basic : first, the unity of empirical science, secondly, purpose in Nature, and thirdly, the nature of art. It is not difficult to see how paramount for an understanding of form is a system of communication—language—through which alone the search for natural law and man's own contribution can reach axiological stature.

Vol. 2 (on mythical thought) consists of four parts : myth as a form of thought ; myth as a form of intuition ; myth as a life-form ; and the dielectic of mythical consciousness. (Incidentally, the jacket of this volume carries the title "Mythical Thinking" instead of "Mythical Thought" as on the book itself.)

Of particular interest to the scientist is the discussion of number in relation to the formative period of mathematics. Philolaus (Fragment 11) says that "the nature of number is the cause of recognition, able to give guidance and teaching to every man in what is puzzling and unknown". Translated into psychological terms such as sensation, intuition and feeling, this brings numerical concepts very close to what the Pythagoreans meant by harmony ; and centuries later, Husserl, originally a pupil of the great Weierstrass, arrived at his 'structural forms', and through them at something like a calibration factor for the resolving power of the mind.

Vol. 3 (on the phenomenology of knowledge) is essentially a return, in expanded form, to the author's earlier (1910) conception of substance and function. But the emphasis this time is on structure and articulation, in fact a kind of ultimate analysis of a *Weltanschauung*. Three divisions are clearly discerned, namely, expressive function, representation, and the building up of scientific knowledge. Projected upon this wide intellectual horizon, the earlier volumes, concentrating upon language and myth, are seen at their true value.

To the scientist, the chapters dealing with the object of mathematics, and the system of modern physics will make substantial appeal. In the latter context, it is slightly unfortunate that for Cassirer 'modern physics' necessarily meant the quantum theory of the 1920's—a momentous but somewhat ephemeral phase, and not over-philosophical. What little weakness the translation has comes out here in slight idiomatic mistakes, such as 'ordinal number' for 'atomic number', and 'exponent of refraction' for 'index of refraction'. But a more fundamental matter is the author's strange omission of the *Axiomatik* of Carathéodory (1908), which must have been known to him when discussing the transition from the crude idea of heat to the modern conception of temperature.

Nevertheless, when all is said and done, these three volumes alone (apart altogether from Cassirer's other papers and books) make an outstanding contribution to epistemology and to the human power of abstraction. It is rather as if "The Golden Bough" had been written in philosophical rather than in historical terms. Scientist and humanist are more closely at one when the theme of knowledge is handled on the grand scale, than they are in the domain of specialized studies. Hand in hand they go, in the quest for an ever more perfect symbolic form, at once rigorous and aesthetically rewarding. F. I. G. Rawlins

Van Nostrand's Scientific Encyclopedia

Third edition. Pp. vii+1839. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 220s.

THE third edition of this well-known work is impressively up to date. It is fresh, comprehensive and altogether a masterly production. The amount of material which has been compressed into the volume is really surprising. Five or more pages are given to many subjects, including television, transistors, carbon, computers, guided missiles, satellites, rockets, jet engines, nuclear reactions and reactors. There are also quite comprehensive accounts of subjects such as water, chlorine, perfumes and topical items such as titanium and radio-astronomy. The list could be greatly extended. There are more than 14,000 articles, covering mathematics, engineering, medicine and the physical and biological sciences. The work is very useful for the professional scientist as well as the layman. The topics covered extend even into specialized fields; on the mathematical side, for example, there are accounts of group representations and of Dirichlet integrals and their use in Fourier series.

In compiling a work of this character the decision what to include and what to exclude must be difficult. The reviewer hesitates to suggest additional topics, but must record his surprise at the omission of articles on information theory and on cybernetics. There is practically no mention of man-made fibres, and only two pages are given to quantum theory and one page to the subject of paper. An account of such topics would make the work larger than its present size. Even now, it is a little cumbersome to handle (it weighs 8 lb.). It would seem, therefore, that for future editions it would be a big improvement if the work could be split into two volumes.

L. S. GODDARD

Symposium on Protein Structure

International Union of Pure and Applied Chemistry, Paris Meeting, 1957. Edited by Prof. Albert Neuberger. Pp. 351. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1958.) 45s. net.

AN account has already been given of the purpose and scope of this Symposium (see *Nature*, 180, 833; 1957). While its object was to assist the Protein Commission of the International Union of Pure and Applied Chemistry in defining 'purity' as applied to protein preparations, its programme was broadened to include many other topics of vital interest to protein chemists at the present time. The emphasis of the papers and discussions, now formally presented in this monograph, is upon the chemical aspects of structure, which include studies of amino-acid sequence and also the more challenging problems of chain-folding and topography of side chains. For certain proteins, all three aspects have been related in some measure to biological activity, especially in the case of the proteolytic enzymes and ribonuclease, and it is, perhaps, this manifold approach which fascinates most. It certainly marks a new phase in the chemistry of biologically active proteins.

Several chapters are devoted to techniques for the separation of proteins, some of which have been almost too successful and have revealed a disturbing micro-heterogeneity. Others emphasize the power of X-rays or of other physical tools to determine absolute structure or variations in it. With one or two exceptions, the contributions are commendably precise and digestible; even a rapid perusal will convince the reader he has been introduced to fields of intense activity and of great reward. The book is a sad reminder, however, that two of its distinguished contributors, Prof. Claude Fromageot and Dr. Rosalind Franklin, are no longer with us.

KENNETH BAILEY

Bacterial Fermentations

By H. A. Barker. (Ciba Lectures in Microbial Biochemistry.) Pp. vii+95. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 24s. net.

IN 1955, the Ciba Lectures in Microbial Biochemistry were established at the Institute of Microbiology, Rutgers University, and in the spring of each year since then a series of three lectures has been given by an invited speaker. The lectures are afterwards published, and so far three volumes have appeared, of which this is the first. Prof. Barker is well qualified to deal with bacterial fermentations since he and a succession of colleagues have made outstanding contributions in this field for more than twenty years. The author makes no pretence of being exhaustive but rather selects those aspects with which he personally has been most concerned.

The first chapter deals with methane-producing bacteria, some of the most difficult species to isolate and maintain in pure culture. Well-merited attention is given to the physiology of these organisms as well as to the chemistry of their fermentations. Then comes a description of butyric acid and butanol fermentations. This includes the brilliant work on the route of synthesis from ethanol of short-chain fatty acids in *Clostridium kluyveri*, an organism isolated by Barker. The last chapter is concerned with fermentations of nitrogenous compounds—amino-acids, purines and pyrimidines. The influence of Barker permeates every branch of this subject; it is good to have this lucid account, and it is fitting that his ability should have been formally recognized by the naming of a species after him—*Methanosarcina barkerii*.

KENNETH MCQUILLEN

Western Australian Wildflowers

Pp. 24 (22 coloured illustrations). (London: Angus and Robertson, Ltd., 1958.) 5s.

WESTERN AUSTRALIA is one of the world's flower gardens, noteworthy alike for the masses of coloured blossom that greet the eye in spring and for the curious shapes and vividly contrasting hues of so many of the flowers. The cover picture of this booklet presents the illyarrie (*Eucalyptus erythrocorys*) with the curiously contorted crimson operculate buds and golden yellow stamens of the open blooms outlined with the blue-green scimitar leaves and set against a blue Australian sky. Inside, a further twenty-one species are illustrated in colour, ranging from the kangaroo paw (*Anigozanthos manglesii*) strangely clothed in green and crimson wool, to the final picture of the sturt desert pea (*Clianthus formosus*), where a black glossy boss on the standard contrasts vividly with the scarlet petals. Proteaceae are represented by the scarlet banksia (*B. coccinea*) from King George's Sound and the curious sea-urchin (*Hakea laurina*) in which the flowers change gradually from cream to crimson. Other floral gems are the blue *Leschenaultia* (*L. biloba*) and the purple enamelled orchid (*Glossodia brunonis*). Mr. C. A. Gardner, Government botanist for Western Australia, has written brief annotations to the pictures, all of which are good representations of the species they portray. The book should help to stimulate interest in the unique flora of Western Australie. It would make a charming small gift for any plant lover, whether botanist or layman. R. MELVILLE

Amber Spiders in European Collections

By Alexander Petrunkevitch. (Transactions of the Connecticut Academy of Arts and Sciences, Vol. 41, July, 1958.) Pp. 97–400. (New Haven, Conn.: Connecticut Academy of Arts and Sciences; Copenhagen: Ejnar Munksgaard, Ltd., 1958.) 7 dollars.

IN this substantial monograph Prof. Petrunkevitch continues his study of amber spiders with an examination of 230 Baltic specimens, chiefly from collections in France, Germany and Denmark. Forty-seven new species are described, two of them belonging to families, Oxyopidae and Hahniidae, previously unknown in amber. The paper is illustrated by 591 text-figures, and the author gives reasons for preferring line diagrams to photographs: in this respect alone do his methods differ from those of former years. He emphasizes the great importance of labelling every piece of amber containing an arthropod with all the relevant data. The paper includes a list of all known amber spiders, of which 160 species are recognized and which belong to 27 existing and 6 extinct families. T. H. SAVORY

The Chemistry of Borates

Part 1. A Review by Peter H. Kemp. Pp. viii+90. (London: Borax Consolidated, Ltd., 1956.) 12*s*. 6*d*.

THIS monograph is a valuable compilation of chemical and physical data on boron oxides, boric acid, and the borates of the alkali metals and of ammonium, calcium and magnesium. Five pages give the essential background on the element itself, and eight pages deal with the perborates, in which the author believes that there is no adequate evidence for hydrogen peroxide of crystallization.

Data in certain cases include enthalpy, entropy and free energy of formation, specific gravity, solubility, melting points, phase-rule diagrams, crystalline form, X-ray measurements, acidity constants and conductivity. Also, there are useful discussions on complexes with organic compounds and on aqueous solutions of the alkali borates.

The literature seems to have been conscientiously searched up to 1955. The book is well printed and no errors have been detected. A. D. MITCHELL

Spot Tests in Inorganic Analysis

By Prof. Fritz Feigl. Fifth, enlarged and revised English edition. Translated by Prof. Ralph E. Oesper. Pp. xiii+600. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd.; Princeton, N.J.: D. Van Nostrand Company, Inc., 1958.) 65*s*.

THIS, the fifth edition of Prof. Feigl's well-known work, is a companion volume to "Spot Tests in Organic Analysis", and now appears as a book in its own right. Improvements and additions are reflected in an increase of the number of pages from 518 to 600.

The chapter by Prof. P. W. West on "Spot Test Techniques" now contains a description of the ring oven method of Weisz, which has been used for the separation of as many as 14 ionic species in a single drop of solution. Other additions include sections on cyanic, hypohalogenous, perchloric, and hyposulphurous acids, and on free aluminium, lead, zinc, tin, arsenic, molybdenum, vanadium, dicyanogen, and tellurium. Some of the twenty-five additional sections in the chapter dealing with the applications of spot reactions are concerned with, as examples, the detection of arsenic, manganese, nickel, titanium, and chlorine in minerals and rocks, the differentiation of calcite from dolomite, the differentiation of minerals containing barium and strontium, the detection of ammonium salts in filter papers, and the detection of iodine in mineral and sea water.

The book is now established as a standard work: due attention is paid to the chemistry of the tests and to the possibility of interferences. Perhaps, for the benefit of the inexpert, greater emphasis might have been placed on some parts of Chapter 1, for example, by italicizing the sentence on p. 14 which reads, "All experience shows that there are but few absolutely reliable and non-misleading tests". C. O. HARVEY

Abstracts of Papers

Given in the Session on Radiation Chemistry at the All-Union Conference on the Application of Radioactive and Stable Isotopes and Radiation in the National Economy and Science, held in Moscow, March 25–April 2, 1957. Translated from the Russian. Pp. 47. (New York: Consultants Bureau, Inc., 1957.) 10 dollars.

THIS volume contains English translations of abstracts of papers given in the session on radiation chemistry at the conference on the application of radioactive and stable isotopes and radiation in the national economy and science held in Moscow in the spring of 1957. Fifty-five papers are abstracted, about 400 words being devoted to each. Nearly all aspects of radiation chemistry are represented, including the gas phase, aqueous and organic systems, polymers and metal corrosion, and there are several papers on special apparatus and techniques. The translations are excellent. G. PORTER

Symposium on Radiation Chemistry

Academy of Sciences of the USSR, Division of Chemical Science, Moscow, 1955. Edited by Prof. N. A. Bakh. Translated from the Russian. Pp. 223. (New York: Consultants Bureau, Inc., 1956.) 100 dollars.

THIS volume contains full translations of twenty-seven papers presented at the Moscow Symposium on Radiation Chemistry. In her preface Prof. Bakh says: "The symposium as a whole presents a picture of the modern development of various aspects of radiation chemistry in our country".

It is divided into two parts dealing, respectively, with transformations in aqueous systems and with transformations in organic substances. The first part contains investigations of the radiolysis of water, oxidation-reduction processes in inorganic salt solutions, sensitization and protection processes, the action of radiations on colloidal solutions, and a paper on radiolysis of liquid oxygen. The second part includes papers on the radiolytic oxidation of organic compounds, radiation polymerization, the actions of radiations on polymers and mass spectrometry.

The authors include P. I. Dolin, V. I. Veselovsky, the late N. B. Miller, N. A. Bakh, M. A. Proskurnin and V. L. Karpov. The general standard is high, and the topics discussed cover most fields which occupy the minds of radiation chemists at present. The translations are excellent, and, although some time has elapsed since the papers were read, they provide a source of information on Russian work in this field which will be very valuable. Unfortunately, the language barrier has been surmounted only by the introduction of an equally formidable price barrier.

G. PORTER

Sourcebook on Atomic Energy

By Dr. Samuel Glasstone. Second edition. Pp. v+641. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 34*s*.

DR. GLASSTONE'S book, prepared under the direction of the Technical Information Service of the United States Atomic Energy Commission, has been available for eight years and a new edition is therefore timely.

The book seems to have been re-set and is on whiter paper; but it has not lost its excellence as a source of scientific and historical information on nuclear energy. Though much of the text has been retained, it has been brought up to date in several respects: the anti-proton and anti-neutron are included, and more is reported on mesons. Unfortunately, the book just missed the complete declassification of thermonuclear research for the production of nuclear energy, though some of the information which was declassified at the time the book was written has been included. A new and very useful chapter is devoted to reactors; it is of the same high standard as the rest of the book, although the account of the considerable British power achievements seems rather short in comparison with their pioneering importance.

Though it is essentially a physics book, some data on the economics of nuclear energy would be valuable in a next edition.

This new edition stands in the forefront of books of its kind; it provides the 'intelligent layman's guide to nuclear energy'.

E. BRETSCHER

Introduction to Meteorology

By Prof. Sverre Petterssen. Second edition. Pp. ix+327. (London: McGraw-Hill Publishing Company, Ltd., 1958.) 52*s*. 6*d*.

FOR the second edition of a book written seventeen years ago Prof. S. Petterssen has gone to much trouble to provide a complete revision addressed to "students who are considering meteorology as a profession" and also to "students in geography, agriculture, aviation and various industries. . . .".

It is a serious and substantial book surveying weather science from instruments and observations through the basic physical processes to synoptic meteorology and world climate, and yet assuming for the reader a previous knowledge of mathematics and physics at first-year grammar school level. What can be done on this basis is quite remarkable provided that scientific explanation is restricted to the qualitative application of physical principles with an occasional simple formula, and, while it may be doubted whether specialist students of meteorology should begin in this way, there is no doubt of the demand for instructional text-books for the use of those much more numerous students whose interests lie primarily in other fields. The geographers, agriculturists, airmen and the like, who are not only interested in weather science but also may very well need to pass examinations in the subject, may count themselves fortunate in that one of our most eminent professors, now president of the American Meteorological Society, has made the effort to write in simple scientific language yet without any suggestion of writing down.

The book is indeed serious, for the author only twice allows himself a frivolous phrase. It is substantial and up to date although a little surprising in that so little is made of those parts of the subject to which the author has himself contributed so much: three-dimensional dynamical and synoptic meteorology. Possibly what one knows the best seems the least adapted to simple treatment. It is also not impossible to pick a few holes in the fabric. Thus I doubt if a small droplet has a high saturation vapour pressure because it resists the advances of vapour molecules in the air (p. 62); the statement that "normally the mixing ratio will increase from the ground upwards" (p. 84) is of course a slip; that "only a small part" of the solar energy is absorbed in the atmosphere and "the bulk is absorbed at the earth's surface" (p. 88) is an exaggeration of a ratio near 1 : 2; "if the oceans were still there would be little difference between the heat exchanges over oceans and over continents" (p. 95) is a remarkable assertion.

But criticisms of this trivial kind are the only ones which can be levelled against what is a reliable and informative introduction to the study of weather and climate suitable for the non-specialist.

R. C. SUTCLIFFE

The Science of Photography

By Dr. H. Baines. Pp. 319. (London: Fountain Press, 1958.) 38*s*. 6*d*.

ALTHOUGH Dr. H. Baines has written mainly for the non-scientist, any reader having little knowledge of the scientific background of photography will find that this book provides a good introduction to the facts and theories underlying all branches of the subject. The very wide field covered includes chapters on history, optics, the chemistry and physics of the emulsion, its preparation, characteristics and processing, colour photography, scientific and technical applications, etc.

This is a very readable book, which bridges the gap between popular articles, sometimes unreliable, on photographic theory and authoritative works unsuitable for the average photographer. C. O. HARVEY

Introduction to the Theory of Determinants and Matrices

By Edward T. Browne. Pp. xi+270. (Chapel Hill, N.C.: University of North Carolina Press; London: Oxford University Press, 1958.) 60*s*. net.

THIS is a good book, well written and well printed. It covers the theory of matrices, including their applications to algebraic forms; and it covers that theory carefully and thoroughly. A novice reading it may find the going heavy, but the development, though sometimes severe, is logical, clear, and fully stated.

The book is aimed primarily at an American audience and "the text is intended for seniors or first year graduate students". In the author's view there is enough material for two semesters work. It would be a stiff course for the novice.

I have two minor criticisms of the book, both due to personal prejudices of my own: I dislike "it is clear that" and I hate small suffixes. Here argument after argument are admirably presented and then, suddenly, my pleasure is destroyed by a redundant "clearly" or "it is clear that". Finally, the print; the type and lay-out of the text and examples reach a very high standard of mathematical printing, but it has one serious fault. While numerical suffixes are excellent, well set and easy to read, the literal suffixes i and j are microscopic. Whenever I came to these suffixes in a close argument I had to reach for a 'spy-glass' to see which was which.

W. L. FERRAR

Combinatory Logic

Vol. 1. By Prof. Haskell B. Curry, Prof. Robert Feys and Prof. William Craig. (Studies in Logic and the Foundations of Mathematics.) Pp. xvi+417. (Amsterdam: North-Holland Publishing Company, 1958.) 42 guilders.

SOME thirty years ago, a new root stretched out into the very foundations of mathematics, or rather, of mathematical logic. This was the combinatory logic of Schönfinkel and Curry. Its particular task is the study of combinators, which are, in fact, a species of constant operator. In formal logic, one is accustomed to the notion of a variable; what is specific to the new discipline is the recognition that this is a complex concept, amenable to analysis. There is a connexion here (perhaps through Gödel's theorems) with the pre-conditions necessary for the design of antomata, and with Polanyi's heuristic field. There are chapters dealing with the several facets of the method, not excluding its bearing upon semantics and the limitations of language.

Where an essentially deductive element is invoked, especially in the use of quantifiers, the adjective 'illative' is introduced. This is a subtle derivation from the past participle of *inferre*, and is thus slightly apart from inference. The build-up of a formal system is well demonstrated for so simple a case as Euclid's "Elements".

Although the authors modestly disclaim any historical background, it is clear how far theorists have progressed beyond Aristotelian principles: they form but a trivial part of this imposing twentieth-century edifice. A great change in the structure of thought has set in, to bring about these highly specialized analytical techniques.

F. I. G. RAWLINS

Inside the Comprehensive School

A Symposium contributed by Heads of Comprehensive Schools in England and Wales. Collected and Edited by the National Union of Teachers. Pp. 235+12 plates. (London: The Schoolmaster Publishing Co., Ltd., 1958.) 12*s.* 6*d.*

SOME at least of the dust raised by the introduction of the comprehensive schools in England and Wales is beginning to settle. Controversy still continues, but this is, generally speaking, more concerned with education and less with party politics than has all too often been the case. Even so, much of the argument is still tragically uninformed. Critics of the comprehensive school still talk of 'mass production', 'submergence of the individual', 'levelling down', and 'lowering of standards'. This timely little book has little to say by way of special pleading. Instead of argument it invites the reader to 'come and see'.

The seventeen contributors to this symposium are all heads of comprehensive schools. Their immediate concern is to describe how they are dealing with the practical problems of every day, the organization of varied courses, all flexible and interlocked, so that the curriculum can be fitted to the pupil instead of fitting the pupil to the curriculum; the breaking down of large numbers into small units, in which the pupil can feel at home, and where he finds personal understanding and appreciation; the pattern of external and internal examinations, which will provide for the vast majority some opportunity for achievement; the development of the social life of the school community; the problem of staff relations and the delegation of responsibility within the hierarchy; the relation of the school to its neighbourhood.

This is an interim report. There are less than fifty comprehensive schools in the whole of Britain, and only a few of these have had time to reach their full development. It will be another ten years before a final assessment can be made. No two comprehensive schools are exactly alike, but they are one in their conscious endeavour to provide the whole range of secondary education to suit the needs of the whole range of abilities from the candidates for open scholarships to the universities down to the educationally almost subnormal.

The writers are enthusiasts with a clear sense of purpose. They know what they are after and why, and for the reader interested in the 'why?' there is a summing up in the final chapter which may well give the hostile critic second thoughts.

ROBERT W. FENN

Five Years' Work in Librarianship, 1951-1955

Edited for the Library Association by P. H. Sewell. Pp. viii+418. (London: The Library Association, 1958.) 60*s.*

"FIVE Years' Work in Librarianship" succeeds "The Year's Work in Librarianship" which ceased publication with the volume for 1950. Arranged in six sections covering, respectively, national and academic libraries, special libraries, public libraries, young people's libraries and library practice, with a miscellaneous section dealing with librarian co-operation, buildings, bibliography, archives, documentary reproduction, etc., it provides a competent and comprehensive survey of developments and trends in Britain and abroad. Information of special interest to the scientist or technologist is somewhat scattered through the chapters dealing with, for example, national libraries, university and college libraries, technical college libraries, medical libraries, industrial libraries, government libraries, the libraries of learned societies and professional bodies and the commercial and technical departments of public libraries. That even the chapter on library co-operation includes no reference to the lack of progress in the establishment of a national lending or reference library for science and techology is not, however, due to oversight on the part of the compilers, but to the strange lack of interest and support shown in the library world as in that of science and technology. So far as the service of science and technology is concerned, the picture is depressing, but a like survey over the two years following 1955 would provide fair evidence that the period of stagnation is past and that the needs of science and technology are now being faced with more imagination, vision and resource.

R. BRIGHTMAN

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A New Method of fractionating High Polymers

We wish to report the results of some exploratory experiments which have been attempted in order to establish a new method for fractionating high polymers.

Zone melting is now recognized as a method of producing materials having a very high degree of purity[1]. Used in the conventional manner, it is found that some impurities are more readily eliminated than others. If, in the case of a high polymer added to a solvent having a suitable melting point, the polymer is eliminated upon zone melting by a process dependent upon some physical parameter which is a function of the degree of polymerization, then this could be used as the basis of a means of fractionation.

In one experiment, a glass tube closed at the base, of 2·2 cm. internal diameter and 30 cm. length, was filled with molten naphthalene. This was first purified by raising the column slowly through a close-fitting heater supplied from a variable voltage source, and the voltage adjusted to give as narrow a molten zone as possible. There was considerable degassing during this process and also purification of the naphthalene, as evidenced by the decreasing opacity of the column after each pass through the heater. After eight passes there was little further change in the purity of the naphthalene contained in the upper portions of the tube.

200 mgm. of polystyrene (*D.C.P.J.*3, Distillers Co., Ltd., Epsom, Surrey. $\overline{M}_n = 80,000$, $\overline{M}_w = 200,000$) was put on the top of the column and taken into solution by arranging the heater and adjusting the heater voltage so that the upper 6 cm. was held in a molten state for 6 hr. This means that initially the polymer was present at 1 per cent concentration at the top of the column. A pronounced opacity, in a region which was formerly transparent, clearly indicated the position of the polymer when the naphthalene solidified. Zone melting was then carried out, using a rate of passage through the heater of 1 in./hr. After one pass it was estimated visually that the polymer had moved 3 cm. down the column, and so was dispersed throughout the upper 9 cm. Eight passes were sufficient to distribute the polymer throughout the whole of the column.

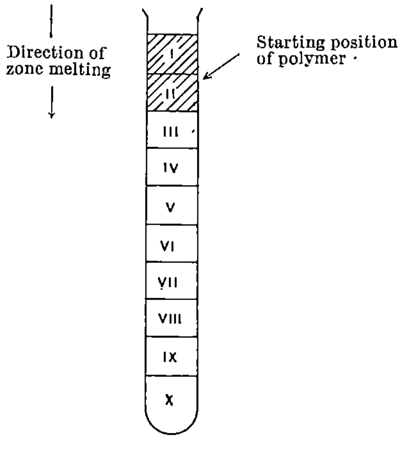

Fig. 1. The column used, showing the initial position of the polystyrene and of fractions recovered

Table 1

Fraction	I	II	III	IV	V	VI	VII	VIII	IX	X
Weight of polystyrene (mgm.)	8·0	7·0	7·5	8·1	6·8	6·4	7·2	6·2	46	106

The polymer was recovered by cutting out the polymer – naphthalene mixture with a flat-faced wood drill so as to produce ten approximately equal portions, and subliming away the naphthalene, which left the polymer in a very fine fibrous state.

The weights of the polymer recovered are given in Table 1, and the positions of the fractions on the column shown in Fig. 1.

The molecular weight and molecular weight distribution of each fraction were assessed qualitatively by turbidimetric titration[2]. In each case 35 ml. of the polystyrene solution, containing 4 mgm./100 ml., was placed in the titration cell, together with 10 ml. of dried methanol. The change in transmission of a light-beam passing through the cell was measured at 1-min. intervals while a further 10 ml. of methanol was added continuously at the constant rate of 0·135 ml./min.

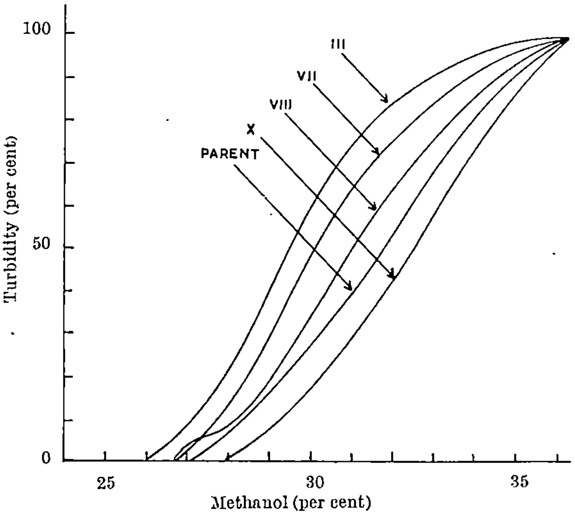

Fig. 2. Turbidimetric titration of the parent polymer and the polystyrene fractions in benzene solution using methanol as precipitant

Fig. 2 shows the change in turbidity of the cell contents with the addition of methanol. The parent material is precipitated over a wide range of solvent – non-solvent ratios, and the materials recovered from the column after zone refining show a much narrower range of precipitation; also the initial precipitation points move in a well-defined sequence.

From this experimental evidence, it can be concluded that the zone melting process can be applied to the fractionation of high polymers. Further investigation of the method is in progress.

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J. C. Robb

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University of Birmingham,
Birmingham 15.

[1] Parr, N. L., "Zone Refining", Royal Institute of Chemistry Monograph (1957).

[2] Melville, H. W., and Stead, B. D., *J. Polymer Sci.*, 16, 505 (1955).

Production of Compounds labelled with Carbon-14 from Carbon-14 Dioxide accelerated in an Electric Field

It is well known that hot radioactive carbon-14 and tritium atoms can be used to produce labelled organic compounds often with very high specific activity[1]. This convenient method requires nevertheless a high neutron flux, often yields a cumbersome mixture of labelled compounds and moreover radiation damage frequently produces undesired effects. For these reasons, I have devised a new method in order to avoid such difficulties.

The procedure developed to prepare labelled compounds is based on the acceleration of carbon-14 dioxide by submitting it to a voltage of 500 V. Under such conditions, carbon-14 is able to react with organic compounds or radicals. In the apparatus illustrated in Fig. 1, the two steel electrodes are removable. A thin layer of the organic material to be treated (about 2–10 mgm.) is spread on the cathode. The two bulbs of the cell have ground-glass joints. The cell is connected to a vacuum line and evacuated for an hour to a pressure of 10^{-6} mm. mercury. After carbon-14 dioxide has been admitted at a pressure of $0 \cdot 5 \times 10^{-1}$ mm. mercury, an applied voltage of 500 V. produces a discharge of 100–150 μamp. The cell is then removed and the organic layer diluted in a suitable solvent. After carrier is added, the active sample is purified chemically until it has constant activity. Indeed, part of the activity of the sample is to be attributed to adsorbed carbon-14 dioxide and is consequently labile. After this radiochemical separation, measurements of the radioactivities isolated are carried out by means of a gas-flow counter. By this method, the following simple organic molecules of the aliphatic and aromatic series have been labelled: acetamide, citric acid, succinic acid, benzoic acid and benzoates.

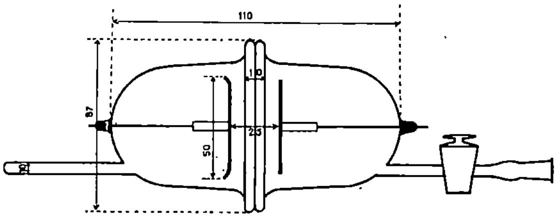

Fig. 1. Diagram of apparatus. Dimensions are in millimetres

In most cases, specific activities are equal to about 0·2 mc./gm. This procedure considerably reduces interference by other adjacent labelled compounds. The specific activities obtained are variable, depending on time of exposure, and increase with the latter. They are also a function of several other factors which are being examined in experiments now in progress. At the same time, the labelling mechanism will be studied. It is hoped that this new labelling technique will be applicable to other radionuclides.

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Hydrogen Overpotential on Germanium Electrodes

Electron transfer reactions at the semiconductor – electrolyte interface are of particular interest because it is not known experimentally whether the reaction kinetics depend upon the bulk electron concentration in the semiconductor. Results of recent measurements of the hydrogen evolution reaction on single crystal germanium electrodes are presented here. The electrode potential (versus the normal hydrogen electrode) was measured under suitable conditions of purity for analysis of the mechanism (Table 1).

Table 1. HYDROGEN OVERPOTENTIAL DATA AT GERMANIUM ELECTRODES (28° C. AND 1 *M* HYDROCHLORIC ACID)

Crystal surface exposed	Bulk electron concentration (cm.$^{-3}$)	Exchange current (amp. cm.$^{-2}$)	$-b$ (mV.)*	$-\Delta\varphi_{i=0}$ (mV.)†
Unknown	4×10^{14}	$1 \cdot 4 \times 10^{-8}$	113	45
Unknown	3×10^{13}	$4 \cdot 7 \times 10^{-6}$	102	1·5
(100)	$\sim 10^{15}$	$(2 \cdot 2 \pm 0 \cdot 3) \times 10^{-8}$	115 ± 12	29 ± 10
(100)	$\sim 10^{12}$	$(2 \cdot 3 \pm 0 \cdot 8) \times 10^{-8}$	109 ± 5	26 ± 6·6
(110)	$\sim 10^{12}$	$(1 \cdot 0 \pm 0 \cdot 2) \times 10^{-9}$	116 ± 2	35 ± 4
(111)	$\sim 10^{12}$	$(1 \cdot 9 \pm 0 \cdot 4) \times 10^{-8}$	148 ± 9	41 ± 20

* $b = 2 \cdot 303\ (\partial\eta/\partial \ln i)$ per decade of current.
† $\Delta\varphi_{i=0}$ is the rest potential of the electrode.

The case where care was taken to ensure that the crystallographic planes were the same on both *n*- and *p*-type germanium (third and fourth entries in Table 1) shows that variation in the bulk semiconductor electron concentration does not produce a corresponding variation in parameters of the hydrogen evolution reaction.

The fact that $\Delta\varphi_{i=0}$ is substantially above zero for most cases shown in Table 1 is interpreted as being due to the dissolution of germanium, that is, the germanium electrode is behaving as a polyelectrode[1]. Such polyelectrode behaviour makes it impossible to obtain the stoichiometric number, ν, for the hydrogen evolution reaction from an analysis of the overpotential – current curve as η goes to zero[2]. However, for one electrode $\Delta\varphi_{i=0}$ is essentially zero and here an analysis of the η versus i curve gives $\nu = 1 \cdot 06$.

Bockris (personal communication) has recently shown that a germanium electrode (supposedly the (110) crystal plane) is covered with a monolayer of adsorbed hydrogen atoms. When this fact is combined with the fact that the Tafel slope is $-2RT/F$ and the stoichiometric number is 1, it can be shown that the only possible simple mechanism for the hydrogen discharge reaction from acid solution is[2]:

$$H_3O^+ + e^- \xrightarrow{\text{fast}} GeH + H_2O$$

$$H_3O^+ + GeH + e^- \xrightarrow{\text{slow}} Ge + H_2 + H_2O$$

(Ge here indicates surface germanium atoms).

This presupposes the mechanism of the hydrogen evolution reaction to be the same on all the germanium crystal surfaces and that the germanium electrode is behaving like a metallic electrode. A more detailed discussion of this work will appear elsewhere.

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Macroscopic Surface Structures formed on Boron upon Solidification

THE purpose of this communication is to report some interesting surface structures that formed on a boron surface upon solidification from the melt. Melting was accomplished by electrical resistance heating of rods of polycrystalline boron about 1 mm. in diameter and several centimetres in length in a helium atmosphere. The current through the rod was slowly increased until it melted at the midpoint at about 2,000° C. and separated into two pieces, at which time heating ceased and the melted boron, held on the tips of the remaining pieces, solidified and cooled below red heat within a few seconds.

These rods were prepared by the reduction of boron tribromide by hydrogen on a tiny 0·025-mm. diameter tungsten filament at about 1,200° C. The main impurity in the rods was that of the tungsten core, which amounted to about 0·04 mole per cent. Emission spectrographic analysis indicated small amounts of calcium, iron, copper, magnesium and silicon amounting to a total of 0·02 per cent by weight.

The photomicrograph in Fig. 1 shows what appears to be a hexagonal spiral pit 0·4 mm. across. Several steps can be seen to extend from the outer edge of the spiral to the centre of the hexagon, where they then taper off and finally disappear. The electrical resistance at room temperature between two tungsten probes placed on the surface of the hexagon was about 50×10^6 ohms. Such a high resistance would be expected for boron but not for tungsten boride. A pyramidal pit approximately 0·1 mm. across at the surface and 0·1 mm. deep is shown in Fig. 2. Another structure observed (Fig. 3) was a highly reflective crystal face in the form of a parallelogram, which contained on its surface an equally smooth oval island several microns in height and about 0·2 mm. by 0·3 mm. across.

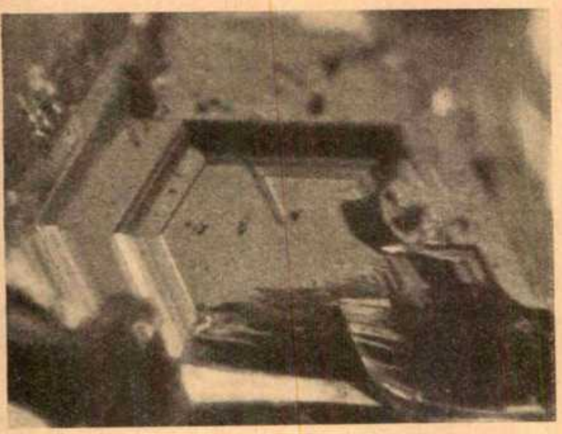

Fig. 1. Hexagonal spiral on boron (0·4 mm. across)

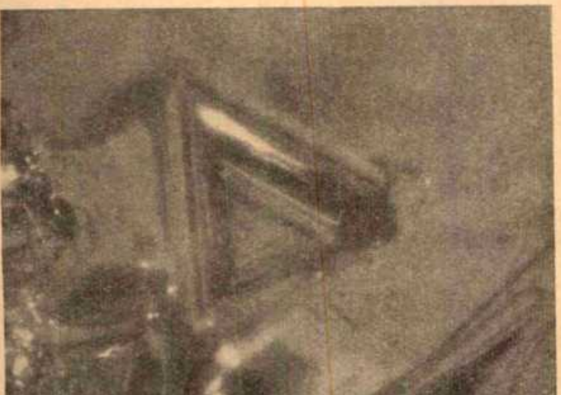

Fig. 2. Pyramidal pit on boron (0·1 mm. across)

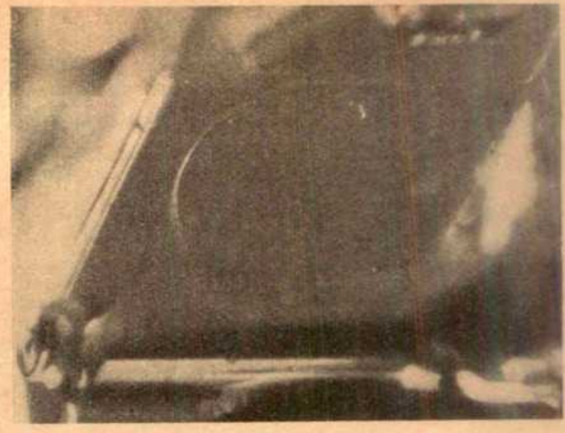

Fig. 3. Oval plateau on boron (0·3 mm. across)

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Extractives from Klinki Pine (*Araucaria klinkii* Lauterbach)

THE wood of mature klinki pine trees (*Araucaria klinkii*) frequently contains pink areas running parallel to the grain. When these areas and those closely adjacent to them are moistened with *N* (or stronger) hydrochloric acid, they become vividly green or green-blue, but after 2–3 days fade to a brown colour. Other acids give either a weaker green colour on fresh samples of the wood or show no reaction. Of the other species of this genus the wood of parana pine (*A. angustifolia* O. Kuntze) frequently shows red-coloured bands, but these do not react in a similar manner when acid is applied to the surface of fresh samples. Dry wood of *A. bidwillii* Hook, *A. cunninghamii* Sweet, *A. excelsa* R. Br., and *A. montana* Bronger et Gris gave no response, but a weak reaction was shown by the woods of *A. cookii* R.Br. and *A. bernierii* Buchh.

When the pink wood of klinki pine was extracted in a Soxhlet with hot methanol, a colourless crystalline material (m.p. 235–38°, $\lambda_{max.}$ 256 mμ, yield 0–2·5 per cent) was soon removed, but the components responsible for the green colour reaction were very slowly removed. The yield of the latter varied between 1·3 and 3·4 per cent, with the smallest yield from the most brightly coloured samples, which also contained less crystalline material.

When the non-crystalline fraction, containing six major components (Table 1), was chromatographed on a cellulose column with 6 per cent acetic acid, compounds *B*—*E* were obtained in a total yield of

Table 1. CHARACTERISTICS OF KLINKI PINE EXTRACTIVES

Compound	R_F values in: 6 per cent acetic acid	Methanol–*iso*propyl-ether–water (ref. 2)	Ligroin–*n*-butyl ether–water (ref. 1)	Benzene–ligroin–methanol–water (*c*) (refs. 3 and 4)	Colour or fluorescence	Colour with: Hydrochloric acid	Wiesner's reagent
A	0	0	0	0	brown (*a*)	green-brown	dark lilac
B	streak	0·95	streak	streak	pink (*a*) mauve-opaque (*b*)	green-blue	transient green-blue
C	0·42	0·90	0·28	0·32	green (*b*)	nil	blue
D	0·57	0·88	0·19	0·67	blue-green (*b*)	nil	lilac
E	0·64	0·84	0·19	0·20	mauve (*b*)	nil	intense pink
F	0·72	0·79	—	—	nil	nil	pale pink
Vanillin	0·69	0·94	0·40	0·77			
Syringaldehyde	0·64	0·90	0·13	—			

(*a*) In daylight; (*b*) in ultra-violet light; (*c*) organic phase.

10 per cent of the fraction. After a few days compound *C* became immobile in 6 per cent acetic acid and then turned green with hydrochloric acid. In order to minimize such changes, compounds *B*—*E* were separated on a number of washed No. 3 Whatman papers with 6 per cent acetic acid (or methanol–*iso*propyl-ether–water with compound *B*). As soon as the sheets had dried the bands were cut out, extracted with methanol and examined.

Compound *B* ($\lambda_{\max.}$ (in ethanol) 225, 265 mμ; $\lambda_{\max.}$ (in sodium ethoxide[5]) 248, 289 mμ) decolorized dilute potassium permanganate, and after alkali–nitrobenzene oxidation on a micro-scale yielded vanillin and *p*-hydroxy-benzaldehyde which were identified by comparison with authentic samples in several chromatographic solvents[2]. The green formed in klinki pine appears to be due to compound *B*, and is different from the paler green formed in spruce wood. Pew[6] considers that the blue component of the latter colour is the result of condensation between a substituted coniferyl aldehyde group and a phenylpropane group in the lignin. The absorption maxima of compound *B* in ethanol – 28 per cent hydrochloric acid at −5° C. were 500 and 640 mμ and are higher than those of compounds previously studied[6].

The absorption maxima of compounds *C*—*F* in ethanol were, respectively, 262, 354; 260, 333; 265, 322; 282, 324, 368 mμ. The maxima of compounds *C*—*E* in sodium ethoxide[5] were 268, 418; 260, 405; 250, 376 mμ, and in ethanol and tetramethyl ammonium hydroxide[1] were 225, 286, 422; 225, 285, 405; 225, 243, 290, 386 mμ, respectively. These results suggest that the compounds contain a substituted cinnamaldehyde grouping and a free hydroxyl[7]. This view was further supported by the decolorization of dilute potassium permanganate, reaction with dinitrophenylhydrazine, a strong reaction with phloroglucinol-hydrochloric acid (Wiesner's reagent) and formation of vanillin and *p*-hydroxybenzaldehyde during alkali-nitrobenzene oxidation (see above). It has been shown[8] that only those aromatic compounds containing an aldehyde group in conjunction with a double bond give a purple colour with Wiesner's reagent, but this is the first time a blue colour has been reported as with compound *C*. The absorption maxima of compounds *C*, *D* and *E* in phloroglucinol – 28 per cent hydrochloric acid[9] at 0° C. were 564, 548 and 537 mμ, respectively, and in resorcinol – 28 per cent hydrochloric acid[9] at 0° C. were 642, 580, 566 mμ.

The pink areas are frequently adjacent to decayed regions in klinki pine. The properties of the above compounds suggest that they are lignin degradation products and that they may be the products of microbiological action.

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Potassium Uptake by Cation-Exchange Resins from Soils and Minerals

THE use of cation-exchange resins for the extraction of soil potassium shows promise of being of value in soil fertility studies[1-4]. Wiklander[1] has discussed the factors which determine the equilibrium distribution of ions between two cation-exchange materials in contact with the same solution. However, the approach to the subject remains empirical because of lack of information on the activity of ions adsorbed on exchanger surfaces. The results with resins in Tables 1 and 2 were obtained by using sufficiently wide ratios of resin to soil or mineral to ensure that practically all the labile potassium was associated with the resin. The potassium analysis was done on the resins (> 60 mesh), which were isolated on a stainless steel sieve (60 mesh) by washing free from finely divided soil or mineral with a jet of distilled water. The washed resin was leached with *N* ammonium acetate and potassium determined in the leachate using an EEL flame-photometer. (Ammonium-exchangeable potassium is defined as that potassium in soil or mineral which is replaced by the ammonium ion during leaching with an excess of neutral *N* ammonium acetate.)

The results in Table 1 on the interaction of 'Amberlite' *IR*-120 resinates with soil slurries show that sodium-resin takes up approximately the amount of potassium that is ammonium exchangeable, while calcium-resin takes up less than the ammonium-exchangeable potassium. A fairly steady state between sodium- and calcium-resins and soil can be attained in 4 days. Considerably more than the

Table 1. THE UPTAKE OF POTASSIUM FROM SOILS BY SODIUM-, CALCIUM- AND HYDROGEN-RESINS COMPARED WITH THE AMMONIUM-EXCHANGEABLE POTASSIUM

Soil	Per cent total potassium in soil	Potassium release (per cent of total in soil)					
		By leaching with *N* ammonium acetate	By intermittent shaking with 'Amberlite' *IR*-120 (1 gm. soil + 2 gm. resinate + 5 ml. water)				
			Sodium-resin	Calcium-resin	Hydrogen-resin		
			4 days	4 days	4 days	14 days	32 days
Saxmundham*							
Plot 4	1·18	1·31	1·27	0·51	1·86	2·37	2·54
Plot 5	1·28	2·19	2·11	1·09	3·12	4·06	4·37
Broadbalk†							
Plot 11	1·10	0·86	0·45	0·18	1·18	1·36	1·36
Plot 13	1·16	2·89	2·93	1·98	4·31	5·43	6·12

* For details, see ref. 5. † For details, see ref. 6.

ammonium-exchangeable potassium can be extracted from soil by hydrogen resin. Generally, but not always, the potassium extracted by hydrogen-resin can continue to increase over a month or more of intermittent shaking. Recent work has shown that soil from the long-term experiment at Saxmundham[5] (Suffolk) which has received no potassium fertilizer for 50 years (plot 4) releases significantly more of its non-exchangeable potassium to crops than does soil from the Broadbalk continuous wheat experiment at Rothamsted[6] (plot 11), which has received no potassium fertilizer for more than 100 years. The amounts of potassium extracted by hydrogen resins are in agreement with this finding. Comparing the potassium-treated soils, the Broadbalk soil (plot 13), which has received a higher rate of application for a longer period than the Saxmundham soil (plot 5), released the larger amount of potassium to hydrogen-resin.

Bremner[7] has shown that ammonium ions fixed in vermiculite can be quantitatively extracted by sodium- and hydrogen-resins. In view of the general similarity in the behaviour of inter-layer ammonium and potassium ions, the effects of resinates on some potassium-containing minerals were examined. The results summarized in Table 2 are not all of direct interest in soil studies but certain behaviour patterns are illustrated. It is only with biotite and potassium-saturated vermiculite that sodium- and calcium-resins extract considerably more than the ammonium-exchangeable potassium present in the minerals. Differences in the vigour of the attack by hydrogen-resin on the various minerals are interesting. Whereas the dioctahedral minerals release little of their non-exchangeable potassium to hydrogen-resin, the tri-octahedral minerals suffer considerable loss of potassium. Biotite is completely broken down by hydrogen-resin in about 10 days with the release of all its potassium. Phlogopite and lepidolite release considerable amounts of their potassium to hydrogen-resin in the course of a few days, but the attack progresses more slowly than with biotite. Such minerals as muscovite and 'hydrous mica', which are known to release their potassium to crops with difficulty, are comparatively resistant to hydrogen-resin attack.

Table 2. THE UPTAKE OF POTASSIUM FROM MINERALS BY SODIUM-CALCIUM- AND HYDROGEN-RESINS COMPARED WITH THE AMMONIUM-EXCHANGEABLE POTASSIUM

Mineral (through 100-mesh sieve)	Per cent-potassium	Potassium release (per cent of total in mineral)				
		By leaching with *N* ammonium acetate	By intermittent shaking with 'Amberlite' *IR*-120 (0·2 gm. mineral + 2 gm. resinate + 5 ml. water)			
			Resinate	1 day	4 days	10 days
'Hydrous mica' (Fithian)	4·1	2·1	Na	2·6	2·9	2·8
			Ca	1·1	1·1	1·1
			H	5·0	5·4	5·5
Muscovite (Delamica)	7·1	1·4	Na	1·5	1·5	1·5
			Ca	1·3	1·3	1·3
			H	2·0	2·3	2·5
Glauconite (Bracklesham)	6·5	3·1	Na	2·5	2·5	2·6
			Ca	1·9	2·2	2·1
			H	3·0	3·8	3·8
Biotite (filings)	6·75	5·3	Na	23·0	24·0	26·0
			Ca	11·0	11·0	11·0
			H	69·0	89·0	99·0
Phlogopite (filings)	6·8	6·6	Na	7·1	7·5	8·1
			Ca	5·1	5·6	5·5
			H	15·0	23·0	43·0
Lepidolite (filings)	6·95	5·6	Na	4·6	5·3	5·3
			Ca	3·6	3·7	4·0
			H	13·0	21·0	37·0
Vermiculite K-saturated	6·19	23·0	Na	49·0	50·0	49·0
			Ca	33·0	35·0	35·0
			H	71·0	75·0	75·0

The hydrogen-resin attack on minerals containing potassium is of a discriminating nature, capable of disclosing the presence of relatively accessible sources of potassium which are not immediately exchangeable. The existing evidence supports the view that hydrogen-resin data may prove to be of value in the assessment of the long-term ability of soils to supply potassium to crops.

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Aluminium Interlayers in Soil Clay Minerals, Montmorillonite and Vermiculite

IN the past few years, some workers[1–3] have described the presence in soils of a vermiculite-like clay mineral with a 14 A. basal reflexion, showing a behaviour intermediate between that of vermiculite and chlorite when subjected to the usual procedures for characterization of clay minerals. This was attributed to aluminium in interlayer positions. Tamura[4], of this laboratory, expanded this mineral by removing the interlayer aluminium with sodium citrate followed by saturation with calcium and solvation in glycerol. He thus showed the montmorillonitic nature of this mineral, which is widely distributed in the Holyoke and Wethersfield soils of the north-eastern United States. Considerable quantities of mineral with a stable 14 A. basal spacing occur in Hartford, Charlton and Gloucester soils in Connecticut. Interlayer aluminium may contribute to the low cation-exchange capacity, toxicity of aluminium and fixation of phosphate so commonly encountered in these soils.

After removal of free iron oxides[5] and interlayer aluminium[4] from the clay fractions of these three soils, the 14 A. component behaved like vermiculite. It gave a 14 A. basal spacing on saturation with magnesium and solvation in glycerol which collapsed to 10 A. on saturation with potassium. In contrast, before extraction of aluminium, the spacing did not collapse to 10 A. on saturation with potassium and drying at 100° C. Intensive treatment with sodium citrate for 12 hr. did not result in any further expansion of the 14 A. spacing, thus establishing the identity of this mineral as vermiculite with aluminium interlayers. Thus aluminium interlayers inhibit the expansion of montmorillonite from 14 A. to 18 A. and resist the contraction of both montmorillonite and vermiculite when saturated with potassium and dried at 100° C.

The formation of aluminium interlayers is essentially chloritization of the expanding type 2 : 1 layer silicates in soils. Therefore, the self-explanatory terms 'chloritized montmorillonite' and 'chloritized vermiculite' are proposed, and are used here for the two species which, after the removal of the aluminium interlayers, are characterized as montmorillonite and vermiculite.

Detailed study of the Charlton silt loam profile shows that the mineral component in the fresh and weathered parent rock (Bolton micaceous schist) with 14 A. spacing is a true vermiculite as shown by the contraction of its interlayer space to 10 A., after saturation with potassium. With the greater intensity of weathering near the surface, aluminium becomes more available, and the aluminium interlayers become increasingly stable. In the *A* horizon, 6–9 hr. of extraction with sodium citrate were required to give sharp 10 A. diffraction maxima after saturation with potassium and drying at 100° C., whereas in the B_2 horizon only 3 hr. of extraction effectively removed the interlayer aluminium. In the 14 A. component of the C_1 horizon, a shorter extraction period sufficed. As the weathering of primary minerals proceeds, aluminium becomes more available, and under the mild acid conditions prevailing in this brown podzolic soils region, it is precipitated in the interlayer spaces of the expanding type 2 : 1 layer silicates.

The end product, that is, chloritization, is the complete regradation of chlorite in soils. A continuous chloritized montmorillonite and chloritized vermiculite–chlorite series may exist. Chlorite formation in soil clays is analogous to the laboratory preparation of chlorite from montmorillonite[6].

In clays from some soils of California which are now saline, broad diffraction effects corresponding to spacings higher than 18 A. were observed with the usual glycerol solvation technique. On treating these soil clays with 2 per cent sodium hydroxide[7], diffraction maxima were resolved to 18 A. It was postulated that during some stage of weathering and formation of these montmorillonites, some cations might have been fixed in the interlamellar positions, thus effectively reducing the layer charge on these montmorillonites in this area, thereby resulting in the observed low-angle diffractions. Expansion of bentonite to 22 A. has been obtained (Sawhney, B. L., and Whittig, L. D., unpublished work) by hydrogen saturation followed by suspension in 1 *N* aluminium chloride solution of *p*H 2·7, washing and solvation in glycerol. Similarly, expansion of bentonite to even larger spacings has been achieved by I. Barshad (personal communication).

Thus aluminium may exist in different forms in the two cases: the aluminium interlayers in natural soil clays and the fixation of aluminium under the above experimental conditions. These forms certainly perform different functions in that aluminium interlayers in soil clays resist the expansion of montmorillonite spacings beyond 14 A., whereas aluminium saturation in the laboratory experiment resulted in the greater expansion of the mineral. It is suggested by Tamura[3] that the presence of $Al(OH)_2^+$ ions, and by C. I. Rich (personal communication) the presence of polymerized basic alumina in the interlayer spaces, are responsible for the non-collapse of the chloritized soil clay minerals. At the *p*H of the solution used by me, Al^{3+} or $Al(OH)^{2+}$ ions may be fixed on either side of the montmorillonite layer, thus reducing the overall net negative charge of the layer and consequently increasing the lattice expansion.

Attempts are being made to purify these aluminium-interlayered species from soil clays, and to introduce aluminium into the interlayer spaces of pure montmorillonite and vermiculite.

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Ionospheric Measurements made at Halley Bay

IONOSPHERIC measurements at the Royal Society Base at Halley Bay (75° 31′ S. 26° 36′ W. geomagnetic latitude 65° 47′ S.) started on April 1, 1957, and some results for the first year's operation are now available. The Base lies in the zone where the magnetic dip is abnormally small (65°) considering the high latitude and the general ionospheric variations are found to be remarkably regular.

Activity due to the incidence of corpuscular radiation, as shown by the occurrence of high absorption during the winter and equinoctial months, reaches a maximum near 0400 L.M.T. (30° W.) and more than two-thirds of the examples are found between 0100 L.M.T. and 1000 L.M.T. The incidence of high absorption is greatly increased at the equinoxes, as is usual for stations lying within a few hundred miles outside the zone of maximum auroral activity. It is remarkable that the auroral radio-echo index at Halley Bay, which mainly represents auroral activity at higher latitudes, shows a similar diurnal variation but shifted in phase towards the earlier hours. This is unexpected, as the corresponding phase-shift with

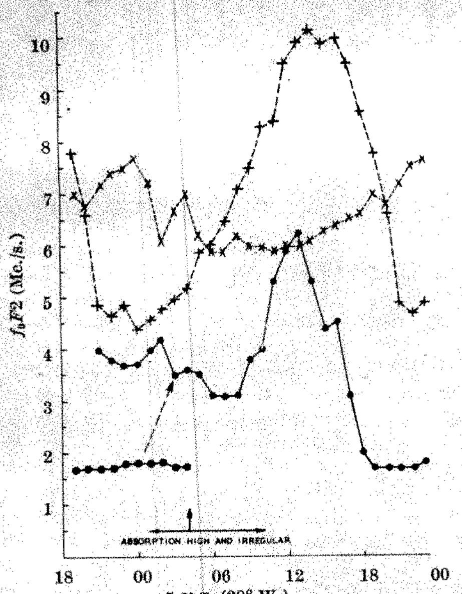

Fig. 1. Monthly median f_0F2 at Halley Bay. ●——●, July (winter); + - - - +, September (equinox); × - - - ×, December (summer)

increase of latitude in the northern hemisphere[1,2] is towards the later hours. The correlations between auroral and ionospheric phenomena appear to be very high, zenith aurora almost always giving high ionospheric absorption accompanied, sometimes, by weak reflexions from heights of about 75–80 km. A thick, group-retarding, auroral E-layer often accompanies auroral activity near the Base.

The detailed results returned to the United Kingdom for the first seven months of operation frequently indicate the presence of consistent recurrent diurnal changes in the F-layer, suggesting that the station is very favourably placed for studying the regular variations of this layer at high latitudes. The ionograms obtained near midnight in winter months show two distinct reflecting structures in the F-region: one which is sequentially continuous (Fig. 1) with the F-layer of the previous day, and the other, which usually first appears with the characteristic shape normally attributed to oblique reflexion from a tilted layer, develops into the F-layer of the subsequent day. Although vestigial reflexions from both structures are usually visible for about eight hours, the change-over from one structure giving the main trace on the ionogram to the other usually occurs in about an hour, near the time marked by the dashed arrow. It is normally complete before the start of the local corpuscular activity, as shown by auroral and blackout phenomena.

The main features of the diurnal variation of the $F2$-layer critical frequency, f_0F2, at Halley Bay are illustrated in Fig. 1. The following points are worth noting: (1) the large diurnal variation of electron density in winter, which is also evident in the total electron content of the layer, having a maximum near noon L.M.T. despite the absence of significant photo-ionization due to solar radiation; (2) the seasonal maxima of electron density in the day found at the equinoxes; these are similar to those found at Port Lockroy (65° S., 64° W.) and Port Stanley (52° S., 58° W.), though in the latter cases the diurnal maximum is reached before instead of after local noon; (3) the small diurnal variation in electron density in summer showing a maximum near midnight L.M.T.; this again is similar, apart from a phase shift, to that found at Port Lockroy; (4) the changes from summer type to winter type diurnal variations near the equinoxes are remarkably sudden, occupying only a few days.

These features suggest, of course, that the diurnal variations of the $F2$-layer near Halley Bay are mainly determined by movements of ionization and not by the recombination processes in the region.

We wish to acknowledge the contributions of Messrs. D. L. M. Cansfield and L. W. Barclay at Halley Bay.

This work was carried out as part of the programme of the Radio Research Board, and this communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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---

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Observations on the Explosion at Ripple Rock

On April 5, 1958, one of the world's largest man-made non-nuclear explosions was fired at Ripple Rock in Seymour Narrows on the west coast of Canada. Briefly, the object of the explosion, which was carried out for the Department of Public Works, Canada, was to remove a twin peaked underwater rock from the centre of a narrow seaway. The method adopted was to sink a 500-ft. shaft on a nearby island and then drive a 2,400-ft. tunnel to points beneath the peaks. Further shafts each 300 ft. high were driven upwards into the rocks and an extensive system of short tunnels was excavated so as to honeycomb the peaks. These tunnels were filled with 1,400 tons of an explosive known as 'Nitramex *2H*' manufactured by the Du Pont Company of Canada. The general arrangement is shown in Fig. 1.

A number of scientific parties observed the explosion and recorded the air blast, the seismic effects, the water waves and the effect on marine life. Among the teams was one from the Atomic Weapons Research Establishment, Foulness, which carried out close-in seismic and air blast measurements, and it is the purpose of this letter to communicate some of the results obtained.

Three types of seismic instruments were used. At the surface of the ground a velocity meter was used which consisted essentially of a mass–spring system in which the damping and natural frequency had been adjusted so that, over the anticipated range of predominant frequencies, the motion of the mass relative to the case was proportional to the velocity of the ground. Cambridge accelerometers were also employed for the surface measurements, these consisting simply of mass-spring systems with a natural frequency, in this case, of 20 c./s. and a damping factor of ½ critical. At underground sites, within the

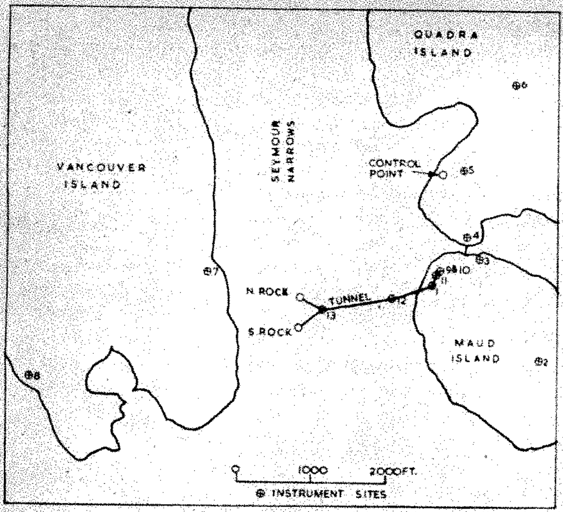

Fig. 1. Ripple Rock project

shaft and along the tunnel, variable-inductance accelerometers were employed. When subjected to acceleration the inductance of the gauges altered and modified the frequency of a local oscillator. The oscillator signals were fed to a central recording site at the top of the mine shaft where they were heterodyned and recorded on magnetic tape. Air blast measurements were obtained by means of mechanical gauges, where the deflexion of a diaphragm under the pressure loading was recorded on a moving film.

All the instrumentation was successful and good results were obtained. Peak accelerations in or out and up or down fitted to an expression of the form:

$$A = 3r^{-2\cdot75} \times 10^8 \ g\text{'s}$$

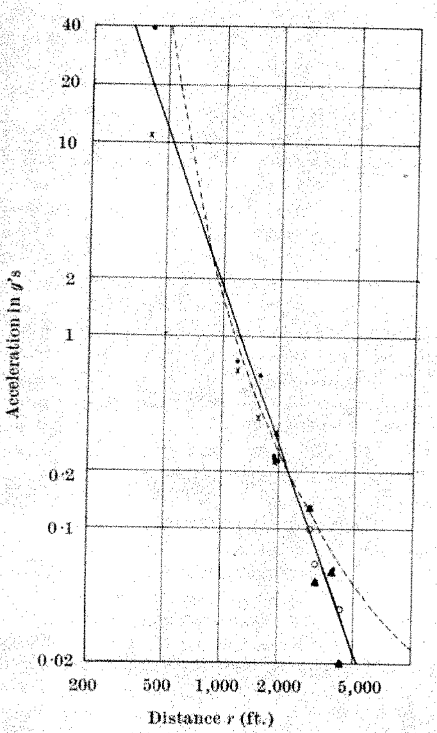

Fig. 2. Acceleration – distance curves. – – –, Prefiring estimate based on Lampson (ref. 1); ——, $3\ r^{-2\cdot75} \times 10^8$; ×, out; ▲, in; ●, up; ○, down

where r is in feet, and agreed well with estimates based on the work of Lampson[1] (Fig. 2). This agreement is remarkable, since Lampson's results were obtained in various types of soils and for the most part with weights of explosive charge of less than 100 lb. Similarly, peak velocities were fitted to an expression :

$$V = 2r^{-1\cdot2} \times 10^3 \text{ ft./sec.}$$

and again agreed well with pre-firing estimates based on unpublished work by the Atomic Weapons Research Establishment with small high-explosive charges. The seismic velocity obtained for the local basalt was 15,000 ft./sec.

An estimate of seismic energy was made from the records and gave 7×10^{16} ergs, about 2×10^{-3} of the available energy calculated on the basis of 4×10^{16} ergs per ton.

The air blast pressure records clearly showed the effect of the 50 feet of rock and water covering the explosive in reducing the peak pressure. The peak pressures of the order of ¼ lb./sq. in. which were recorded at 2,000 ft. were about one-fifteenth of the pressure which would have been expected from the same weight of charge exploded at the surface and were equivalent to the pressure that would have been recorded from only 0·6 tons of T.N.T. fired in this position. The records have a relatively sharp front, although not as sharp as the normal blast wave, but they also have a negative phase (pressure lower than atmospheric) which is much larger in amplitude than that normally encountered in explosive work. This pronounced negative phase will explain the marked Wilson cloud chamber effect which was visible on ciné records of the event.

To assist the long-range seismic measurements undertaken by the Dominion Observatory, Ottawa, an estimate of the time of firing was obtained from the times of arrival of the first seismic pulse in terms of observatory time broadcast for the event by the Canadian Broadcasting Corporation. The resulting firing time was 9.31.02·05 Pacific Standard Time with an estimated accuracy of ± 0·02 sec.

The assistance of the local contractors and constructors and many others is gratefully acknowledged. A great deal of the preliminary work was done by teams from the Suffield Experimental Station of the Defence Research Board of Canada, and to them, and in particular Mr. A. P. R. Lambert, field superintendent, we are deeply indebted. Thanks are also due to the Director of the Atomic Weapons Research Establishment, Aldermaston, and to the Canadian authorities for permission to publish this work.

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Presence of 6707 A. Radiation in the Twilight Sky

SINCE August 5, 1958, a patrol spectrograph at Hallett Station in Antarctica has frequently shown the presence of a strong emission line in the region of 6705 A. from the twilight sky. Following a report of this, a grating spectrograph at Invercargill, New

Zealand, was exposed on September 5, 1958, to the radiation coming from the twilight sky between the horizon and 20° altitude, on a bearing of 175° (true). A feeble line at 6707 ± 2 A. was detected on this occasion, and on several subsequent occasions. The use of a minus ultra-violet filter confirmed that the line was in the first-order spectrum. Exposures at varying states of twilight showed that the line was enhanced in twilight at about the same time as the well-known sodium *D*-line enhancement. Hallett station has also observed this twilight enhancement, both morning and evening, from the date of the first detection.

The measured wave-length of this line does not correspond to that of any atomic oxygen or nitrogen line[1], and there is no structure visible that would classify the emission as one of the molecular bands recognized in the spectra of auroræ and airglow[2,3]. The twilight enhancement in a manner similar to that of sodium, occurring at approximately the same time, suggests that the line arises from the $2^2S - 2^2P$ transition in the lithium atom (wave-length 6707·8 A.)[4]. This line is the first member of the principal series of lithium, and thus would be excited resonantly by solar radiation in the same manner as the D-lines of sodium. If this identification is accepted as correct, then the concentration and height of the lithium atoms may be estimated from a preliminary examination of the spectra.

The Invercargill plates show the emission line as a just detectable feature, not strong enough for microphotometry. Until the Hallett spectra are available for precise measurement, accurate estimates of the height and intensity of the lithium line are not, therefore, possible. However, in the middle of August, the lithium emission was observed at Hallett to be of about the same intensity as the total *D*-line emission, and a visual estimate of the density on the Invercargill plates suggests that, in September, the 6707 intensity was of the order of one-tenth the total intensity of the *D*-lines. The oscillator strengths of the lithium 6708 and of sodium 5890 + 5893 are similar[5], and a simple calculation shows that equal intensities of the lithium and sodium lines would result from a lithium concentration 5 per cent that of sodium. The calculation takes into account the Fraunhofer lines in the solar spectrum, and the Rayleigh scattering and ozone absorption in a model atmosphere used previously in colorimetric determinations of the twilight sky[6]. Nicolet[7] gives the total number of sodium atoms above 70 km. as 6×10^9 per cm.^{2}. This suggests that, in August, lithium was present in the upper atmosphere over Hallett to the extent of 3×10^8 atoms per cm.^{2}. The concentration to the south of New Zealand had apparently fallen to 3×10^7 atoms per cm.^{2} by early September. (These concentrations correspond to a total quantity of lithium in the upper atmosphere equal to 20 and 2 kgm. respectively, assuming a uniform distribution over the Earth's surface.)

Calculation of the effect of Rayleigh scattering and ozone absorption on the transmission of radiation through the model atmosphere shows that, after sunset at sea-level, 6708-A. radiation penetrates about 5 km. lower into the atmosphere than does 5893-A. radiation. Applying this correction to measurements of the altitudes above the horizon of the sodium and lithium enhancements observed at different stages of twilight at Hallett, Table 1 gives the estimates of the difference in height between the sodium and lithium layers.

Table 1

Date (1958)		Height of lithium – height of sodium (km.)
August	13	0
	14	-1
	16	-1
	18	-3
	19	-5
	20	-5
	21	-5
	24	-7
	26	-5
	28	-5
September	5	-7

It seems likely that the height of the lithium layer has decreased, relative to the height of the sodium layer, by approximately 0·4 km. per day during the period covered by the observations.

The investigation, of which this is a preliminary report, is part of the research programme of the New Zealand Department of Scientific and Industrial Research. The high-dispersion spectrograph is on loan from the Air Force Cambridge Research Center, through Carter Observatory, Wellington, for the New Zealand International Geophysical Year auroral programme.

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Sept. 23.

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Behaviour of the Present Sunspot Cycle

In a communication dealing with the behaviour of the present sunspot cycle, Visser[1] states that the changes in an unspecified ionospheric index are nearly independent of the simultaneous changes in the relative sunspot number, and, in particular, that the rapid increase in the sunspot number in 1957 was not accompanied by a corresponding increase in the ionospheric index.

Visser suggested that the reason for the lack of correlation between the two indices may be that ionospheric phenomena depend on the occurrence of solar eruptions, the incidence of which is not necessarily greatest when sunspots are most numerous. While the radiation emitted during solar eruptions is often known to influence the ionosphere, it is the relatively permanent background radiation which is the principal controlling factor. In view of this, it would be expected that ionospheric indices and sunspot numbers should behave in a broadly similar manner.

Tables have recently been prepared of the monthly mean values of two ionospheric indices, I_E and I_{F2}, which are based respectively on the degree of ionization in the E and $F2$ layers[2]. The unsmoothed values

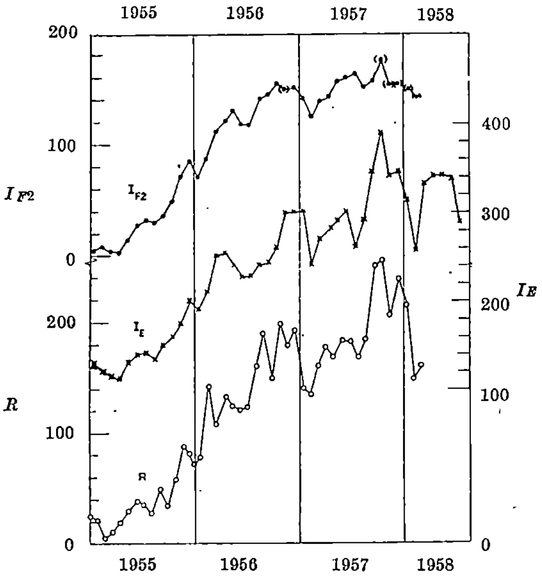

Fig. 1. The behaviour of the present sunspot cycle as indicated by the sunspot number and two ionospheric indices. ●—●—●, ionospheric index, I_{F2} [( ) doubtful value] ; ×—×—×, ionospheric index, I_E ; ○—○—○, rotational mean sunspot number R (after Visser)

of these indices are shown in Fig. 1 for the period January 1955 to date, together with the rotational mean values of the sunspot number taken from Visser's diagram. Both the ionospheric indices and the sunspot numbers vary in a very similar way, and even the smaller irregularities in the trend are sometimes visible in all three curves.

Visser also refers to the secondary oscillations in the sunspot number which occurred during the period 1947–50. These oscillations can also be clearly seen in even the unsmoothed values of the index I_{F2} for this period, and there is some evidence for their existence in the years following the 1938 peak in solar activity[3]. It is important to remember that, although ionospheric ionization is subject to large seasonal changes, there is no significant annual component in the indices I_E and I_{F2}. Hence, the fact that, at the epochs mentioned above, the oscillations in the ionospheric indices have a period of roughly one year cannot be attributed to a residual seasonal component in these indices.

The work described above was carried out as part of the programme of the Radio Research Board and is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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MR. C. M. MINNIS's communication elucidates matters considerably.

The "unspecified ionospheric index" is that determined at De Bilt (daily sums of eight 3-hr. data).

At first I used the f_0F2 data of Slough and Washington[1,2], but since the data from De Bilt coincided fairly well with those of f_0F2 at Washington (ref. 2, Fig. 8) I therefore left the Slough and Washington data and took those of De Bilt, which were directly at my disposal. I must agree now that, for the present purpose, the simple I index of De Bilt does not suffice. As regards the secondary peaks, I find that their period certainly does not have a duration of about one year. I have now completed the investigation from 1863 to date. All sunspot cycles, Nos. 11–19, show the same character with considerable secondary peaks. A broad scattering from 6 to 19 synodic rotations being present, it is evident that there is no question of a regular period. Yet this feature of the sunspots may point to some interesting secondary solar action.

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Maxwell Fish-eye treated by Maxwell Equations

THE so-called Maxwell fish-eye[1] is a non-homogeneous lens the index of refraction of which varies according to the relation :

$$n(r) = \frac{2}{1 + (r/R)^2} \tag{1}$$

where R denotes the radius of the sphere, and r the radial distance measured from the centre of the sphere. If a point source is located at the rim of the sphere the lens will focus the rays to another point on the rim at the opposite side. The lens was invented by James Clerk Maxwell in 1860 based upon the method of geometrical optics. It was the year before his enunciation of the electromagnetic theory of light.

In a previous communication[2] the problem of the Luneberg lens was treated rigorously as a boundary-value problem within the framework of the Maxwell equations. It was indicated therein that the same technique can be used to investigate the Maxwell fish-eye. The core of all such radially stratified problems is to resolve two differential equations of the form :

$$\frac{d^2S_n}{dr^2} + \left[k^2\varkappa(r) - \frac{n(n+1)}{r^2}\right]S_n = 0 \tag{2}$$

and

$$\frac{d^2T_n}{dr^2} - \frac{d\varkappa(r)}{\varkappa(r)dr}\frac{dT_n}{dr} + \left[k^2\varkappa(r) - \frac{n(n+1)}{r^2}\right]T_n = 0 \tag{3}$$

where $k = \dfrac{2\pi}{\lambda}$ is the wave-number and $\varkappa(r) = n^2(r)$.

The constant n in these two equations is an integer. The two functions S_n and T_n are associated, respectively, with the transverse electric and the transverse magnetic modes in the analysis of the problem.

For the Maxwell fish-eye, if one substitutes equation (1) into equations (2) and (3) the resultant differential equations can be reduced to the hypergeometric equation by two transformations. Thus, if one denotes :

$$\rho = kr, \text{ and } \rho_0 = kR$$

then by changing the independent variable to ξ defined by :

$$\xi = -\rho^2/\rho_0^2$$

and let:

$$S_n = \xi^{n+1/2}(\xi - 1)^{\mu}U,\ T_n = \xi^{n+1/2}(\xi - 1)^{\mu-1}V$$

where:

$$\mu = \tfrac{1}{2}\left(1 + \sqrt{1 + 4\rho_0^2}\right)$$

it can be shown that the functions U and V satisfy, respectively, the following two equations:

$$\xi(\xi - 1)U'' + [(2\mu + \beta)\xi - \beta]U' + \alpha U = 0 \quad (4)$$

and

$$\xi(\xi - 1)V'' + [(2\mu + \beta)\xi - \beta]V' + (\alpha - \tfrac{1}{2})V = 0 \quad (5)$$

where:

$$\beta = n + \tfrac{3}{2}, \text{ and } \alpha = \beta\mu + \rho_0^2$$

The prime denotes the derivative of the function with respect to ξ.

Equations (4) and (5) are identical, in form, to the hypergeometric equation:

$$\xi(\xi - 1)W'' + [(a + b + 1)\xi - c]W' + abW = 0 \quad (6)$$

By comparing equations (4) and (5) with (6) it is relatively simple to determine the constants a, b, and c in terms of α, β, and μ. For the analysis of the Maxwell fish-eye we only need the hypergeometric function $F(a,b,c,\xi)$, which is regular at $r = 0$.

So far as numerical work is concerned it is, of course, not an easy task. Until such results are available the detailed behaviour of the lens is not known. I wish merely to direct attention to the fact that the Maxwell fish-eye can formally be treated as a boundary-value problem, based upon the equations which Maxwell formulated.

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Separation of the Condensing Enzyme of *Aspergillus niger* from Acetyl Coenzyme *A* Deacylase and Citridesmolase and the Effect of Magnesium Ion on the Purified Fraction

THE condensing enzyme found in various tissues has been generally found to require magnesium for its activity. However, an exception was reported by Ramakrishnan and Martin[1], who found that the condensing enzyme of *Aspergillus niger* does not require magnesium and is, on the contrary, inhibited by it. Horecker and Mehler[2] suspected that the presence of citridesmolase as a contaminant might be responsible for this inhibition. Further, the presence of acetyl coenzyme *A* deacylase in cell-free extracts of *A. niger* has been recently detected in this laboratory and the enzyme purified[3]. It will be noted that this enzyme also needs magnesium for optimal activity and that the presence of this enzyme as a contaminant in the condensing enzyme is likely to cause its inhibition by magnesium. I have therefore reinvestigated the problem of the magnesium requirements of the condensing enzyme with reference to the presence of contaminants.

Calcium gel supernatant was prepared from cell-free extracts of *A. niger*, *N.R.C.* 233, according to the method of Ramakrishnan and Martin[4]. The preparation was tested for the condensing enzyme, acetyl coenzyme *A* deacylase and citridesmolase activities with and without magnesium ion. The assay system for these enzymes have already been described[3-5]. The results are given in Table 1.

Table 1. EFFECT OF MAGNESIUM ION ON CONDENSING ENZYME, ACETYL COENZYME *A* DEACYLASE AND CITRIDESMOLASE ACTIVITIES OF CALCIUM GEL SUPERNATANT FRACTION PREPARED FROM *A. niger*

Magnesium ion added	Magnesium ion content (μgm./ml.)	Specific activity of		
		Condensing enzyme	Acetyl coenzyme *A* deacylase	Citridesmolase
–	0·1	30·0	7·0	13·8
+	96·2	18·0	11·8	14·2

The contamination of the condensing enzyme preparation obtained by Ramakrishnan and Martin's method[4] with acetyl coenzyme *A* deacylase and citridesmolase is evident from Table 1. It also appears that magnesium ion inhibits the condensing enzyme and accelerates acetyl coenzyme *A* deacylase activity but does not have any effect on citridesmolase activity. Thus the inhibition by magnesium ion observed in the condensing enzyme preparation might have been due to the presence of acetyl coenzyme *A* deacylase.

The next step, therefore, was to remove these two contaminants from the condensing enzyme and study the effect of magnesium ion on the purified enzyme.

It was possible to obtain the condensing enzyme in a highly purified form as follows.

The methods of preparing cell-free extract of *A. niger*, *N.R.C.* 233 and ammonium sulphate fraction (40–60 per cent) have already been described[4]. The ammonium sulphate fraction was frozen overnight and thawed out and centrifuged. To the clear supernatant was added 0·5 volume of calcium phosphate gel, stirred for 15 min. at 0° C. and centrifuged at 6,000 r.p.m. for 20 min. To the supernatant was added 0·5 volume of alumina gel, stirred for 15 min. at 0° C. and centrifuged.

This procedure was found to yield a highly active condensing enzyme that appears to be completely free from acetyl coenzyme *A* deacylase.

The cell-free extract, the ammonium sulphate fraction, the calcium gel supernatant and the alumina gel supernatant were tested for the activity of the condensing enzyme as well as acetyl coenzyme *A* deacylase with and without magnesium ion.

Table 2. EFFECT OF MAGNESIUM ION ON CONDENSING ENZYME AND ACETYL COENZYME *A* DEACYLASE

Enzyme preparation	Mg++ added	Mg++ content (μgm./ml.)	Specific activity of:	
			Condensing enzyme	Acetyl coenzyme *A* deacylase
(1) Cell-free extract	–	0·2	0·63	1·6
	+	96·2	0·50	2·2
(2) Ammonium sulphate (40–60 per cent saturation) unfrozen	–	0·4	15·0	6·5
	+	96·6	10·5	9·1
(3) Ammonium sulphate fraction (40–60 per cent saturation) frozen and thawed	–	0·4	15·2	0·8
	+	96·6	10·6	1·1
(4) Calcium gel supernatant from 3	–	0·1	30·0	0·5
	+	96·1	18·0	0·7
(5) Alumina gel supernatant from 4	–	0·1	42·0	—
	+	96·1	5·1	—

It can be seen from Table 2 that the condensing enzyme in all the fractions is inhibited by magnesium ion whereas acetyl coenzyme *A* deacylase is activated. It will also be observed that the purified condensing enzyme is still found to be inhibited by magnesium ion. This suggests that the condensing enzyme of *A. niger* may be different from that obtained from other sources in respect of its magnesium requirement.

My thanks are due to Miss Mary Clements, Division of Applied Biology, National Research Council of Canada, for the gift of the strain of *A. niger*, *N.R.C.* 233, and lyophilized *E. coli*.

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A Rapid Paper Chromatographic Procedure for the Quantitative Determination of Hydroxyproline

In a recent communication[1], we described a descending paper chromatographic procedure for the quantitative determination of hydroxyproline which required a solvent development of 40 hr. Using horizontal paper chromatography at an elevated temperature, comparable results have been obtained after development for only 4 hr.

Four standard hydroxyproline solutions (*p*H 6·5) containing, respectively, 0·050, 0·075, 0·100 and 0·125 µgm. of amino nitrogen are applied to the paper in 0·5 µl. volumes. The unknown solution is spotted (in 0·5 µl. volumes) to fall within the 0·50–0·125 µgm. range of the standard solutions.

Whatman No. 1 filter paper buffered[2] at *p*H 8·4 and measuring 12 cm. × 17 cm. is used. The origin is 2·5 cm. from one end. A 1·5-cm. tab, folded at right angles to the paper, is inserted into the solvent trough.

The chromatographic chamber and the manner in which the filter paper strip is supported in a horizontal position have been described[3,4].

The developing solvent is prepared at 22° C. in a temperature-controlled room by equilibrating equal volumes of redistilled *m*-cresol (Matheson Co., Inc., practical grade) and *p*H 8·4 buffer (0·067 *M*)[2]. The buffer solution must be within ± 0·1 *p*H to obtain the separation reported here. The solvent-rich phase is placed in the trough and the bottom of the chamber is covered with the buffer-rich phase. The covered chamber is housed in a mechanical convection oven at a temperature of 60° C.

After spotting, the filter paper strip is placed in the chamber and a solvent development of 4 hr. at 60° C. separates hydroxyproline from the other common amino-acids. Following solvent development, the chromatogram is dried for 1 hr. at 60° C. using a mechanical convection oven, dipped in a ninhydrin–isatin solution, and the colour of the hydroxyproline spots is developed by placing the chromatogram in an oven at 60° C. for 15 min. The colour reagent is composed of 270 mgm. of ninhydrin, 130 mgm. of isatin and 2 ml. of triethylamine made up to 100 ml. with water-saturated *n*-butanol. The merits of this hydroxyproline reagent have been discussed previously[5].

The maximum densities of the hydroxyproline spots are measured with a 'Densichron' transmission densitometer (Model 3835 *B*, W. M. Welch Scientific Co., Chicago) using a 1-mm. diameter aperture and no filter. A standard curve is prepared by plotting the logarithm of the known concentrations against the densities. The concentration of hydroxyproline in the unknown solution is then calculated by referring to the standard curve. The standard curves are not reproducible from one paper strip to another, and the standards must be run each time on the same chromatogram with the unknown.

Table 1. ACCURACY AND PRECISION OF THE RAPID HORIZONTAL PAPER CHROMATOGRAPHIC DETERMINATION OF HYDROXYPROLINE

Chromatogram	Calculated concentration (mgm./100 ml.)
1	48·7
2	48·7
3	49·6
4	48·7
5	45·9
6	47·7
7	49·6
8	44·0
9	46·3
Average	47·7
Standard deviation	2·21
Deviation from theoretical value, 46·8 mgm./100 ml. (per cent)	1·9

The accuracy and precision of this rapid paper chromatographic procedure were established by determining the hydroxyproline content of a solution, *p*H 6·5, containing eighteen common amino-acids. The average value of nine chromatograms, 47·7 mgm./100 ml., differed from the theoretical value by 1·9 per cent (Table 1). The standard deviation was 2·21 mgm./100 ml. These values are in good agreement with an error of 0·9 per cent and a standard deviation of 1·41 mgm./100 ml. obtained when the solution was assayed using a descending paper chromatographic procedure[1]. The main advantage of the horizontal procedure is the shortening of the solvent development time from 40 hr. to 4 hr.

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Anæmia and Liver Damage in X-Irradiated Animals

A number of authors have found disturbances in various liver functions, damage to the liver in the form of fatty degeneration, and increase in the total liver fats in various mammals after total body irradiation with lethal doses of X-rays. According to Ellinger[1] these changes occur after irradiation with doses exceeding *LD*80, and the mechanism of their origin is not yet quite clear. Severe anæmia after irradiation, and resulting hypoxia of the liver and of other organs, might also occur. We have investigated this possibility, and have found that after total body irradiation with

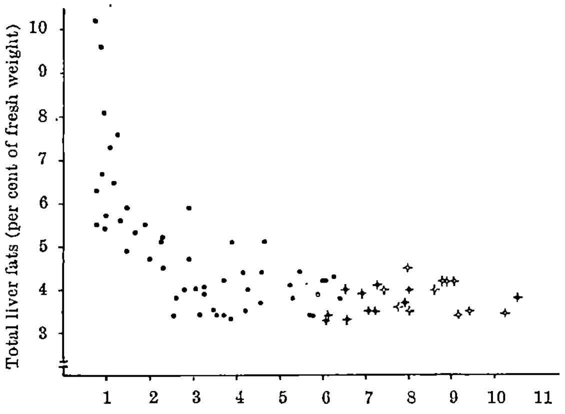

Fig. 1. Relation between the number of red blood cells and the amount of total liver fats in irradiated rats. +, Normal animals; ●, irradiated animals

high doses a striking relation exists between the decrease in red blood cell count and the amount of total liver fats.

Rats of the Wistar strain and white mice of the *H* strain, males and females, were subjected in several experiments to total body X-irradiation (180 kV., 15 m.amp.; 1 mm. aluminium, 0·5 mm. copper; dose-rate, 60 r./min.) with doses of 500–640 r. Food (Larsen diet) and water were given to the animals *ad libitum*. Between the eighth and the twelfth day the irradiated animals and the non-irradiated controls were killed by ether anæsthesia. Red cell counts were made on blood taken from the right heart chamber; in the liver samples, fats were repeatedly extracted with alcohol–ether (3 : 1) and re-extracted with chloroform. The fats were then determined by iodimetric titration after combustion in a solution of potassium dichromate and sulphuric acid[2]. In 22 normal rats the fresh liver tissue contained 3·77 ± 0·345 per cent total fats; for 33 mice the figure was 4·06 ± 0·544 per cent.

The results are summarized in Figs. 1 and 2. From Fig. 1 it is evident that in rats with a red blood cell count less than 2–2·5 million/mm.³, there is, as a rule, an increased amount of fats in the liver. Similarly, for mice (Fig. 2) the liver fats increase when the red cell count drops to less than 4–5 million/mm.³.

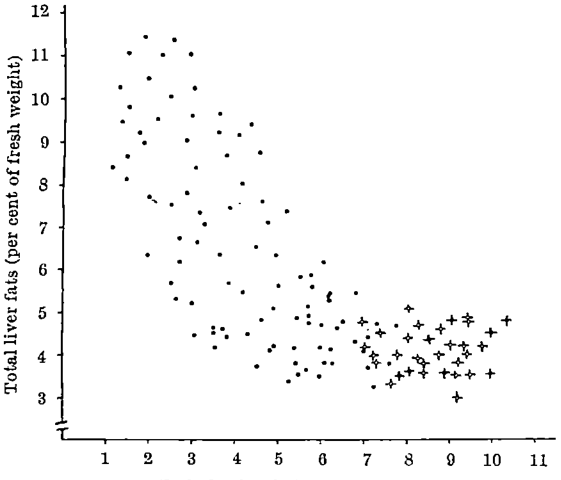

Fig. 2. Relation between the number of red blood cells and the amount of total liver fats in irradiated mice. +, Normal animals; ●, irradiated animals

We may therefore assume that until the critical figure is reached the organism is capable of compensating the deficiency of red blood cells and of hæmoglobin by various mechanisms, such as shifting the dissociation curves of oxyhæmoglobin to the right or increasing the pulse frequency and pulse volume; in severer anæmia the compensatory mechanisms are probably already insufficient. The difference between the critical values for rats and for mice might be related to the findings of Dowdy *et al.*[3], that mice are more sensitive to a decrease of oxygen pressure in the air than rats.

The relation between the drop in the red blood cell count and the rise in the amount of liver fats is not linear in either rats or mice. The partial rectification of the correlation curve of these two values for statistical evaluation is attained by using logarithms of both values. The correlation between the logarithms of the red cell count and the logarithms of the amount of liver fat in rats ($r = 0·87$) is statistically highly significant ($t = 9·3$; $P < 0·0001$). Similar results are obtained for mice.

Clinically, it is known that severe anæmia and the consequent lack of oxygen in the organs causes, among other things, damage to the liver. After irradiation, however, this question has, so far as we know, not been investigated. The correlation is very striking, and certain facts in the literature (for example, that irradiated animals are less resistant to long exposure to reduced oxygen pressure[4]) lead us to assume that severe hypoxia of the tissue after irradiation is fatal to the organism.

Work on this problem is continuing.

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Effect of Thyroid Pre-treatment on the Mortality of X-Irradiated Mice

There is difference of opinion with respect to the changes of basal oxygen consumption in animals subjected to X-irradiation and to their significance. Some have observed increased metabolism after irradiation, whereas others have not been able to corroborate these results[1].

We have studied changes of metabolism during adaptation, as a means of ascertaining the activity of metabolic processes. Oxygen consumption is measured immediately after putting the animal into the chamber. As the animal adapts itself to the conditions of the measuring procedure, the changes in oxygen consumption are determined by the condition of the nervous system of the animals. Measuring adaptation consumption of oxygen gives results that are more easily reproducible than serial measurements of the 'basal metabolic' condition, which are more difficult[2,3]. During this work, we have found that animals for which general irradiation is fatal show a reduction of the adaptation consumption of oxygen before their death (L. N., unpublished work). This reduction can be interpreted as failure of the capacity for adaptation of the nervous system, and it can be ameliorated by feeding the animals with thyroid prior to the irradiation. This favourable effect upon the adaptation metabolic capacity of the animals resulted also in higher survival of the irradiated mice.

White male mice of mean weight 30 gm. were fed in groups of 20 with dried thyroid (0·2 gm. gl. thyreoideae siccae per 100 gm. of food). After 20 days, this thyroid pre-treatment was stopped, and five days later the animals were irradiated simultaneously with a control series. They were subjected to this treatment in groups of six, the dose of whole-body X-irradiation being 600 r. (Super Sanax apparatus, 180 kV., 15 m.amp., 1 mm. aluminium, 0·5 mm. copper, target distance 43 cm., 60 r. per min.).

Group 1 (autumn 1957): mortality at 30 days for the control group ($n = 78$) was 71 per cent, while with the treated group ($n = 74$) it was 55 per cent, this difference being statistically significant ($P < 0\cdot05$). Group 2 (spring 1958): mortality at 30 days for the control group ($n = 87$) was 91 per cent, whereas for the treated group ($n = 70$) it was 40 per cent, this difference being highly significant ($P < 0\cdot01$).

The difference in death-rate in the two groups could be observed in the course of the second week, that is, during the period of maximum mortality. As to changes of weight, there was no difference between the experimental group and the control group immediately before irradiation and in the post-irradiation period. Prior to irradiation, as well as on the third and tenth days after irradiation, the adaptation consumption of oxygen was determined for groups of six mice. Fig. 1 gives the statistically significant difference in the average rates of the adaptation consumption of oxygen on the third and tenth days ($P < 0\cdot005$) between the experimental group and the control group.

Such pre-treatment of mice with thyroid, therefore, reduces the post-irradiation mortality. Our results cannot be compared with the experiments of W. W. and F. Smith[4], owing to the different period of feeding which was used. The latter authors showed that when animals are fed with thyroid beginning a week before irradiation and continuing during irradiation, there is a decreased rate of survival of the animals. In our experiments conditions were such as to prevent an absolute increase in consumption of oxygen after irradiation when compared with the pre-irradiation values. We found instead a limited reduction of the adaptation consumption of oxygen. We believe this is due to a relative increase in the activity of the sympathetic nervous system, stimulated by the thyroid treatment.

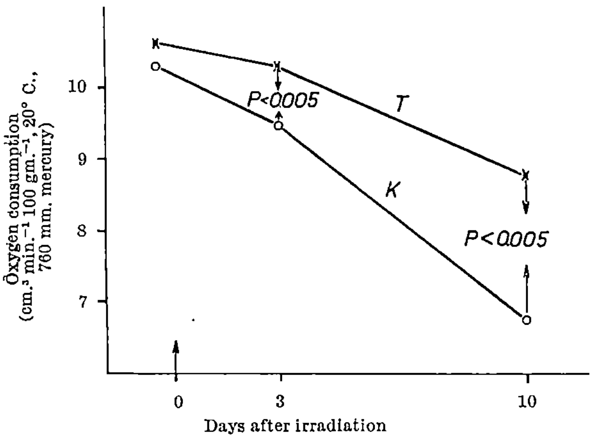

Fig. 1. Changes in oxygen consumption in the adaptation phase (*T*, experimental group; *K*, control group). Ordinates: values of oxygen consumption (cm.³ min.⁻¹ 100 gm.⁻¹, 20° C., 760 mm. mercury dry air). Abscissa: time of examination in days after irradiation

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Chemistry of the Rhodopsin Cycle

In 1950, Wald, Durell and St. George[1] found a shift of the absorption maximum in a rhodopsin–glycerin mixture illuminated at − 73° C., and they proposed lumi-rhodopsin as the first intermediate in the rhodopsin cycle. They concluded that lumi-rhodopsin is stable at low temperature, and that when warmed to room temperature in the dark it is converted to a mixture of regenerated rhodopsin and retinene + opsin in roughly equal amounts. We believe[2], however, that the rhodopsin remaining unbleached after low-temperature illumination should not be regarded as having been regenerated from retinene and opsin, but could be recovered directly from lumi-rhodopsin. This communication is a further report of the recovery process.

Cattle rhodopsin solution was prepared as described in our previous paper[2]. After being kept in dry ice-acetone (− 78° C.) or liquid air (− 186° C.) for 5–6 min., rhodopsin solution was illuminated by a fluorescent lamp (2,000 lux, 20 min.), and then immediately raised to room temperature (23° C.) and left in the dark for 1 hr. The absorption spectrum was determined with a spectrophotometer before and after complete bleaching (8,000 lux, 20 min.). The difference spectrum thus obtained was regarded as a measure of the total amount of rhodopsin in the solution.

Fig. 1 shows that the optical density (at 500 mμ) of rhodopsin solution illuminated in dry ice-acetone is 51·4 per cent of that of the non-illuminated solution; in liquid air the corresponding figure is 69·2 per cent. (The solution in dry ice-acetone was orange-red in colour, while that in liquid air was pinkish red.) Furthermore, when the solution illuminated in dry ice-acetone is transferred to liquid air and after 10 min. illuminated again (2,000 lux, 20 min.), the relative amount of rhodopsin is 59·4 per cent, that is, intermediate between the two former values. On the other hand, if the solution is placed in liquid air in the dark after illumination in dry ice-acetone, the relative amount of rhodopsin remains at 51·4 per cent.

The relation between the re-exposure time and the amount of rhodopsin is shown in Table 1. The optical density (at 500 mμ) increases in accordance with the re-exposure time within 30 sec. and then tends to remain constant.

Table 1. OPTICAL DENSITIES (AT 500 Mμ) OF CATTLE RHODOPSIN SOLUTIONS

	Non-illuminated	Illuminated in Liquid air	Illuminated in Dry ice-acetone	After illumination in dry ice-acetone, re-illuminated in liquid air for: 5 sec.	10 sec.	30 sec.	2 min.	10 min.	20 min.
Optical density	0·176	0·114	0·089	0·092	0·093	0·099	0·098	0·103	0·099
Total rhodopsin (per cent)	100	64·8	50·6	52·3	52·8	56·3	55·7	58·5	56·3

Recently, Hubbard and St. George[3] have observed that squid rhodopsin was regenerated from meta-rhodopsin in the light, and they consider that light would promote the interconversion between rhodopsin and meta-rhodopsin, both forming a steady-state mixture. Hubbard and Kropf[4] extended the mechanism to vertebrate rhodopsin and suggested that light is able not only to convert rhodopsin into all-trans lumi- or meta-rhodopsin but also to isomerize all-trans chromophores of lumi- or meta-rhodopsin to a steady-state mixture of stereoisomeric chromophores, all of which are still combined with opsin molecules. The neo-*b* and iso-*a* fraction of this mixture may correspond to rhodopsin and iso-rhodopsin respectively, so that the other isomers (labile fraction) must be regarded as responsible for 'lumi- or meta-rhodopsin'.

Though we carried out no experiments on the isomerization of chromophores, our experimental results suggest that a short-lived intermediate must be produced in any state before rhodopsin will be converted into 'dry ice-acetone illuminated rhodopsin' (lumi-rhodopsin[1]). We assume the existence of 'liquid-air illuminated rhodopsin' which can be clearly distinguished from 'dry ice-acetone illuminated rhodopsin', not only in colour but also in the relative amount of rhodopsin remaining after incubation at room temperature. It is worthy of note that the relative amount of rhodopsin increases when 'dry ice-acetone illuminated rhodopsin' is illuminated in liquid air. In other words, light acts on lumi- or meta-rhodopsin, making it return to 'liquid-air illuminated rhodopsin', that is, the intermediate which is considered to be stable at liquid-air temperatures. We shall call this phenomenon 'photo-recovery'.

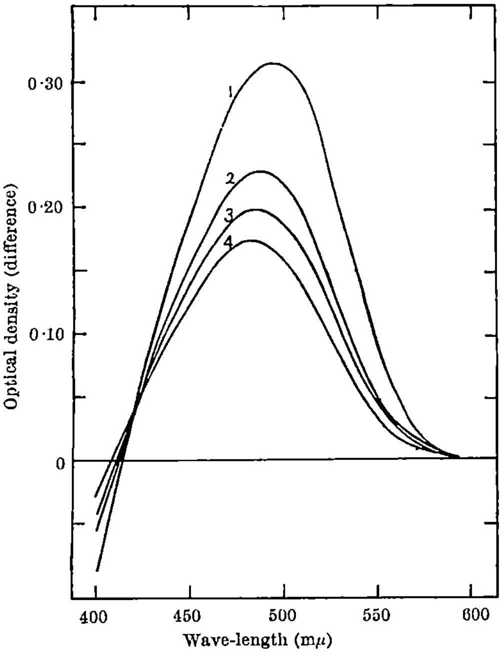
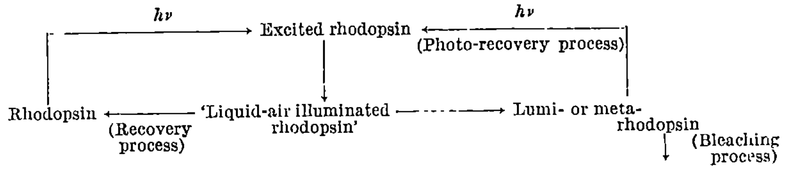


Fig. 1. Difference spectra of cattle rhodopsin solutions. 1, Non-illuminated; 2, illuminated in liquid air; 3, after illumination in dry ice-acetone, re-illuminated in liquid air; 4, illuminated in dry-ice acetone

Based on these considerations, we propose a scheme for initial changes in the rhodopsin cycle shown below. When lumi- or meta-rhodopsin absorbs light energy in liquid air, it changes into the excited state (photo-recovery) and then into 'liquid-air illuminated rhodopsin'.



The recovery process and the photo-recovery process may play important parts in rod vision. This will be the subject of our future investigations.

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Biochemical Characteristics of Dog Semen

EARLY observations on canine spermatozoa by Leeuwenhoek[1], and Spallanzani[2], although mainly confined to microscopic studies of sperm morphology and motility, included also experiments on various factors affecting sperm activity, and a successful attempt to perform artificial insemination in the bitch. A perusal of the existing literature, however, concerning the chemical composition of dog semen shows that the present knowledge is still very incomplete[3,4]. Moreover, the early analyses of dog semen were carried out mainly with whole ejaculates, although, as already shown by Ivanov[5], dog semen is ejaculated in three fractions, the middle one containing the highest concentration of spermatozoa.

The present study was undertaken in an attempt to extend the information available. The findings are based on an examination of semen from three mixed-breed dogs, using the artificial vagina designed by Harrop[6]. Average figures are quoted in order for the first, second, and third fractions, and the figure for the total ejaculate is in brackets.

The electrolytes determined in dog semen included (m.equiv./l.):

Sodium	164,	149,	154	(133)
Potassium	5·5,	11·5,	7·3	(7·9)
Calcium	1·6,	0·9,	0·4	(0·5)
Magnesium	1·8,	0·8,	0·3	(0·5)
Chloride	154,	169,	160	(150)
Bicarbonate	2·2,	4·2,	2·3	(2·7)

Dog semen also contained (mgm./100 ml.):

Acid-soluble phosphorus	0·7,	29·3,	0·8	(7·4)
Copper	0·26,	1·26,	0·40	(0·51)
Zinc	2·20,	18·40,	7·63	(7·69)
Iron	0·03,	0·06,	0·02	(0·05)
Total reducing substances (expressed as hexose)	15·0,	17·0,	8·0	(20·5)
Fructose	0·47,	2·30,	0·34	(0·56)
Total protein	2,000,	7,000	1,500	(3,000)

It was found that the composition of semen, even if obtained from the same dog, was subject to considerable variation, in particular as regards the levels of sodium and chloride. It was also found that, with a few exceptions, the second, or sperm-rich fraction, appeared to contain the highest concentration of any one constituent.

A noteworthy characteristic of dog semen is the very low level of total reducing substances (20·5 mgm./100 ml.), the majority of which do not disappear on incubation with fermenting yeast, and therefore must not be regarded as fermentable sugar or fructose. However, although dog semen as ejaculated contains no more than a trace of fructose, the fructolytic ability of canine spermatozoa, as expressed in the fructolysis index, was found to be quite appreciable —1·2 mgm. fructose were utilized by 10^9 spermatozoa in 1 hr. at 37° C. Other metabolic studies included measurements of sperm respiration. The oxygen uptake (in the presence of air) was found to be 230 µl. per 10^9 spermatozoa in 1 hr. at 37° C. The dependence of the respiration of canine spermatozoa on the cytochrome system is strongly indicated by the results of spectroscopic analysis. The examination of a suspension of dog spermatozoa in glycerol at the temperature of liquid air revealed the presence of a complete cytochrome system, including the absorption bands of cytochromes *a*, *b*, and *c*.

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Effect of Drugs on Emotional Behaviour in Rats

A NUMBER of workers have investigated, in experimental animals, the effects of tranquillizing drugs on learned behaviour motivated by fear. John *et al.*[1] have suggested that reserpine inhibits conditioned avoidance behaviour by interference with learned associations, whereas Weiskrantz[2] believes that reserpine reduces sensory perception. Miller[3] suggested that chlorpromazine reduces fear motivation and that this is independent of its sedative action or of an effect on motor co-ordination.

Since there have been few reports concerning the action of these drugs on unlearned behaviour, some results obtained on emotional behaviour are of interest.

Defecation has frequently been used as a measure of emotional behaviour in the rat and the validity of this measure has been recently reviewed by Broadhurst[4]. Furthermore, emotional defecation is correlated with the acquisition of a conditioned 'anxiety' response[5] and it has been found that chlorpromazine reduces this conditioned defecation[6].

Male rats, fed and watered *ad libitum*, were placed for the first time in an unfamiliar environment, an 'open field'[7], consisting of a small arena 3 ft. 6 in. in diameter. The number of fæcal boluses excreted in 3 min. was used as the index of emotionality[4] or fear, while ambulation was recorded as a measure of sedation. Other types of behaviour such as preening, which may be a 'displacement reaction'[8], and rearing, which was correlated with ambulation, were also noted.

In each experiment the behaviour of treated rats (usually ten per dose) was compared with that of controls and the significance of the results was assessed by *t* tests.

The field was illuminated more brightly at the centre (700 foot candles) than at the periphery (30 foot candles), and this caused the rats to venture into the centre less often than when even illumination (30 foot candles) was employed. This may represent a fear reaction to the light[4].

Chlorpromazine produced a graded and parallel reduction in all types of behaviour (Table 1), but the treated rats did not venture into the centre of the field any more than did the control rats. Reserpine produced similar effects and both drugs caused obvious drowsiness. In contrast to these results, prochlorperazine reduced ambulation, rearing and preening, yet had no significant effect on defecation, and produced very little drowsiness in the doses used.

Table 1. EFFECT OF DRUGS ON EMOTIONAL BEHAVIOUR IN RATS

	Mgm./kgm. subcutaneously	Percentage of control value ± standard error			
		Ambulation	Defecation	Rearing	Preening
Chlorpromazine (1 hr. after injection)	0·5	78 ±30	100 ±20	67 ±16	89±25
	1·0	60 ±15	83 ±22	62 ±16	46±18
	2·0	38 ±13	49 ±15	37 ±14	32±18
Reserpine (18 hr. after injection)	0·5	59 ± 8	91 ±31	63 ±13	140±23
	1·0	16 ± 8	22 ±24	20 ±12	43±17
	2·0	0·7± 7	2·8±22	2·5±12	39±19
Prochlorperazine (1 hr. after injection)	2·5	52 ±13	73 ±25	48 ±22	78±26
	10·0	20 ±13	105 ±25	20 ±20	38±28

In order to investigate the possibility that the reduction in defecation with chlorpromazine and reserpine was due to a peripheral action of the compounds, experiments were carried out to investigate their effects on non-emotional defecation, that is, defecation in rats which had become accustomed to their accommodation (the rats were housed singly in large tins). In these experiments the rats were deprived of food from the time of the injections. Reserpine (2 mgm./kgm.) markedly increased the number of fæcal boluses eliminated, compared with controls ($P < 0·001$), with a maximum effect 2 hr. after the injection. However, fæcal elimination 6–23 hr. after injection was normal ($P > 0·3$). Chlorpromazine (20 mgm./kgm.) increased elimination from 5·6 ± 1·5 (standard error) fæcal boluses per rat (controls) to 9·7 ± 0·9 fæcal boluses per rat (treated animals), throughout 17 hr. following injection. In another experiment 10 mgm./kgm. of chlorpromazine had no effect. When tested in the 'open field' on the second day of the experiment, that is, about 19 hr. after chlorpromazine and 25 hr. after reserpine, the treated rats defecated less ($P < 0\cdot02$) than the controls.

These experiments show that both drugs increased non-emotional defecation. Therefore the reduction in emotional defecation is unlikely to be due to a peripheral constipating effect. Furthermore, the reduction in emotional defecation by reserpine was not due to a decrease in food consumption.

Several other centrally acting drugs have been tested in the 'open field' with the following results.

Benactyzine (4–16 mgm./kgm. subcutaneously) increased ambulation and reduced defecation but the latter effect may be due to a spasmolytic action[9]. Meprobamate, methylpentynol, and pentobarbitone modified behaviour only at doses which caused ataxia, the chief effect being an increase in ambulation. Dexamphetamine resembled lysergic acid diethylamide, the most interesting effect being a reduction in ambulation at the centre of the field with doses (5 and 0·5 mgm./kgm. subcutaneously respectively) having no significant effect on overall ambulation: this suggests potentiation of the stress response to the light.

Since chlorpromazine and reserpine reduced emotional behaviour only at doses which caused sedation, these results suggest that the principal behavioural effect of these drugs in experimental animals is one of sedation, while the reduction in fear-motivated behaviour observed in these experiments and in experiments involving conditioning techniques, is secondary to the sedation.

The results obtained with prochlorperazine support this view since the compound produced less drowsiness than did chlorpromazine in the doses used, and did not reduce defecation. Courvoisier *et al.*[10] also found that prochlorperazine was less active than chlorpromazine in various tests of 'sedation' yet it had a greater cataleptic action. This latter observation could explain why prochlorperazine reduced the motor reactions to the environmental stress, but not the visceral reaction.

It is possible, however, that the measures of fear adopted are insufficiently sensitive to detect effects at small doses.

My thanks are due to Dr. D. R. Maxwell for useful discussion and to Mr. R. B. Hutchins for valuable technical assistance.

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Zinc Deficiency induced by Mercury in *Coffea arabica*

A zinc deficiency has been induced in *Coffea arabica* trees in Kenya Colony as a result of spraying with fungicidal formulations containing mercury in organic combination. The symptoms were first observed in October 1957 on coffee trees which had been treated with certain mercurial sprays against coffee berry disease (*Colletotrichum coffeanum* Noack).

The first effects were observed on trees in field trials which had been treated with phenyl mercury acetate, and appeared 4–5 months after the last application of the fungicide. These effects took the form of a severe leaf scorch such as is often associated with the use of phytotoxic materials. Later, other symptoms which affected the growth of the shoots and leaves were observed.

The internodes were abnormally short and some of the youngest leaf pairs were reduced in size, giving the end of the shoot a bunchy, rosetted, appearance. The leaves were often chlorosed in a manner typical of zinc deficiency in this crop, and, in extreme cases, were reduced to the mid-rib. In addition, there were other cases where one pair of leaves was abnormally elongated.

Since it was known that certain of these symptoms are characteristic of zinc deficiency in *Coffea arabica*. leaves from affected trees and from adjacent unsprayed and unaffected controls were analysed spectrographically for zinc content. The results of these preliminary analyses are given in Table 1.

Table 1

	Zinc content (p.p.m.)
Affected leaves (taken from trees which had received six applications of phenyl mercury acetate)	3·6
Control leaves (unsprayed)	14·0

Comparative analyses were afterwards made of first, second, third and fourth leaf-pair samples, counting from the apex of the shoot, collected from both sprayed and unsprayed trees. The figures obtained from these analyses are given in Table 2.

Table 2

	Leaves from sprayed shoots (p.p.m. zinc)	Leaves from unsprayed control (p.p.m. zinc)
First leaf pair	13	31
Second leaf pair	14	20
Third leaf pair	9	19
Fourth leaf pair	8	7

The phenyl mercury acetate sprays are, therefore, associated with a greatly reduced zinc content at the distal ends of the shoots.

The difference in the zinc content of both the controls and the sprayed material shown in Tables 1 and 2 above is attributed to the time of sampling. For the analyses shown in Table 1, material was collected towards the end of the dry season, whereas the material which yielded the results shown in Table 2 was collected eight weeks later, after a period of rain.

Formulations containing mercury in soluble form, such as phenyl mercury acetate, have been observed to cause more severe symptoms than, for example, the relatively insoluble phenyl-mercury-8-hydroxyquinoline.

It is also evident from observations in the field that shoots which are most exposed to the direct rays of the sun suffer more severely. Trees under shade trees show far less severe symptoms.

Similar symptom effects to those described above have been observed by one of us on *Coffea arabica* in the Kivu District of the Belgian Congo following spraying with a formulation containing arsenic. It would thus appear that the effect is not confined to sprays containing mercury. The mechanism of this effect, together with other aspects of the phenomenon, are being studied.

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Labelling of Cells in Thoracic Duct Lymph of the Guinea Pig after Tritiated Thymidine

Since tritium gives precise localization in radioautographs[1], and in view of the fact that thymidine is generally believed to be specifically incorporated into deoxyribonucleic acid[2], tritiated thymidine has been employed in recent years to an increasing extent for the study of cellular proliferation.

The studies now reported have been conducted on a series of 22 male guinea pigs, of mixed strain, weighing approximately 400 gm. each. Tritiated thymidine with specific activity of either 0·36 or 1·9 curies/mM. was given in doses of 1 μc. per gm. body-weight, and thoracic duct lymph and blood were studied in smear preparations at various periods afterwards. Suspensions and sections were also prepared of thymus, cervical and mesenteric lymph nodes, spleen and bone marrow. Coated radioautographs were prepared by the method of Belanger and Leblond[3].

Labelled lymphocytes began to appear in lymph during the first hour after the administration of tritiated thymidine, and were thereafter present for several days. To begin with, labelled large lymphocytes are mainly in evidence, though some medium lymphocytes are also seen. Gradually, the size distribution of the labelled cells changes, so that in one experiment the size distribution during the first hour was 47 : 7 : 0 (that is, 47 large, 7 medium and 0 small lymphocytes), in the second hour 48 : 20 : 0, in the third hour 57 : 35 : 4 and in the fourth 75 : 64 : 20. Labelled small lymphocytes began to appear during the third hour and then gradually increased. In the lymph of another animal, obtained at 14 hr. after thymidine, the size distribution among the labelled cells was 47 : 75 : 54, and in lymph collected after 25 hr. it was 33 : 65 : 94. After a single injection of thymidine, a steady stream of labelled lymphocytes, ranging from 2·0 to 7·0 per cent of the total thoracic duct cells, enters the blood over several days. These findings, which differ from those of Gowans[4] in the rat, suggest the continuous liberation of cells from a precursor pool. Labelled small lymphocytes were also found in the blood by the seventh hour, and in view of the work of Bond *et al.*[5], are presumably cells which have entered the blood after labelling in the lymphoid tissues.

Examination of the lymphoid tissues shows active synthesis of deoxyribonucleic acid from the outset, especially in the germinal centres. Though accurate quantitation is not yet possible, it seems clear that there is extensive new formation of lymphocytes; and that a large number of the small lymphocytes i thoracic duct lymph must be newly formed cells The results do not support the concept either o massive re-utilization[6] or large-scale recirculation[7].

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Some Structural Characteristics of Myelinated Nerve Fibres

In a previous communication[1] observations were made concerning some errors attendant on methods which have been used in the quantitative examination of myelinated nerve fibres.

A technique demonstrated[2] to the Anatomical Society of Great Britain and Ireland on February 28 has been used to investigate the size relation of the axon and its myelin sheath[3]. During examination of the sural nerve and the nerve to the medial head of the gastrocnemius muscle of the rabbit some points of general interest not previously published have emerged.

5-μ transverse sections of fresh nerve were examined using a polarizing microscope, and measurements of axonal and external diameter made.

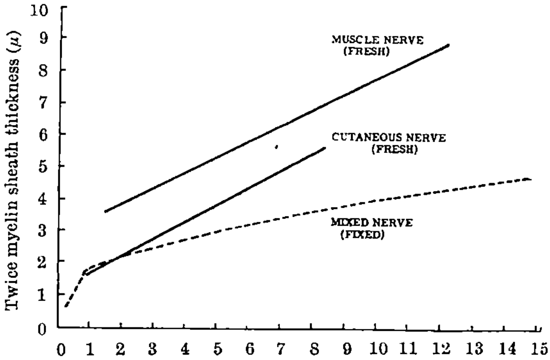

Fig. 1. Composite graph of twice myelin sheath thickness against axon diameter for a muscle nerve and a cutaneous nerve of the rabbit. A line derived from Sanders (ref. 4) for fixed and stained fibres of the mixed peroneal nerve of the rabbit is included for comparison

The lines representing fresh muscle and cutaneous nerves (Fig. 1) are calculated regression lines which have been tested for goodness of fit. The standard error of estimate of sheath thickness from axon diameter is 0·49μ and 0·57μ for the gastrocnemius muscle nerve and the sural nerve respectively. Full results, scatter diagrams and a statistical analysis will be published elsewhere.

It can be concluded that within the range of fibres studied: (1) in both muscle and cutaneous nerves a linear relationship exists between myelin sheath thickness and axon diameter; (2) the ratio of axon diameter to sheath thickness differs in cutaneous and muscle nerves; (3) the similarity in slope demonstrates that a unit increase in axon diameter is accompanied by an increment of sheath thickness which is similar for muscle and cutaneous nerves; (4) differences in slope and position of the line derived from Sanders[4] may be interpreted as resulting from admixture of muscle and cutaneous fibres in the peroneal nerve and the differential shrinkage inherent in processing.

The observed differences between muscle and cutaneous nerves make it desirable to investigate the effects of processing on each type of nerve separately. Such experiments are in progress.

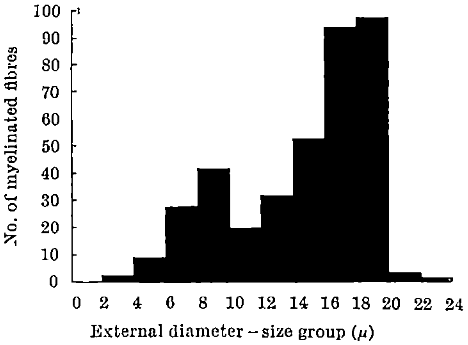

Fig. 2. External diameter-size frequency distribution of nervus gastrocnemius medialis of rabbit, exhibiting bimodality

A histogram (Fig. 2) illustrating the external diameter – size frequency distribution of the nervus gastrocnemius medialis of the rabbit prepared from a 5μ, fresh, transverse section, exhibits the typical bimodal form which has been demonstrated for fixed and stained preparations[5]. If, however, a histogram illustrating the internal diameter – size frequency distribution is constructed in a similar manner a unimodal form results (Fig. 3).

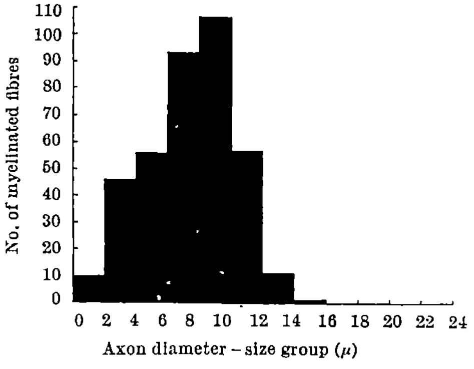

Fig. 3. Internal diameter – size frequency distribution of nervus gastrocnemius medialis of rabbit, exhibiting unimodality

In conclusion we wish to stress the following points: (1) histological techniques in current use should be subject to more critical evaluation; (2) our present results should be considered in investigations into impulse conduction, and the processes of growth and regeneration; (3) for many purposes simple external diameter measurements are inadequate; (4) for a more comprehensive study one should consider the interrelation between external diameter, internal diameter, internodal distance, and features of the nodal apparatus for a specific fibre population.

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Giant Nerve Cells and Fibres in *Arenicola claparedii* (Polychæta)

OUR knowledge of the giant nerve cells and fibres of the Arenicolidae still rests on the pioneer work of Gamble and Ashworth[1]. These authorities described the structure and arrangement of the giant cell system in considerable detail and stated that they found it in all the species with one exception: "In *A. claparedii* there is, curiously enough, no trace either of giant cells or of giant fibres". They gave no details of the observations on which the statement just quoted was based, and no figures of the minute anatomy of the nerve cord in *A. claparedii*.

The conclusions of Gamble and Ashworth were accepted by later writers[2]. However, I recently decided to check the absence of giant nerve cells and fibres in *A. claparedii* because of the lack of detail on this point in their publication. It is, of course, well known that giant nerve cells and fibres are structures of great functional importance, and as all the tailed lugworms appear to live in much the same way, their absence in one only of the species would indeed be remarkable if it were true.

My observations were made on Neapolitan material. Transverse and sagittal serial sections were cut. They show giant fibres and giant cells arranged in the manner usual in the Arenicolidae, except only in one respect mentioned below. The structures approach those of other species in size. The cell in the accompanying photograph of a sagittal section has a cell body measuring 0·038 mm. by 0·029 mm. and a nucleus 0·013 mm. in diameter. In *Arenicola marina*, according to Gamble and Ashworth[1], "The cells measured 0·04 mm. in length and about 0·02 mm. in breadth".

The peculiarity of *A. claparedii* is that its giant cells lie in an unusually lateral position, as shown in the transverse section shown in Fig. 1. In other species, they occupy a nearly mid-ventral position within the cord. This may be correlated with a difference in the position of the cord as a whole, which lies deep to the circular muscle layer in most species, but outside that layer and in close contact with the epidermis in *A. claparedii*. If it may be sup-

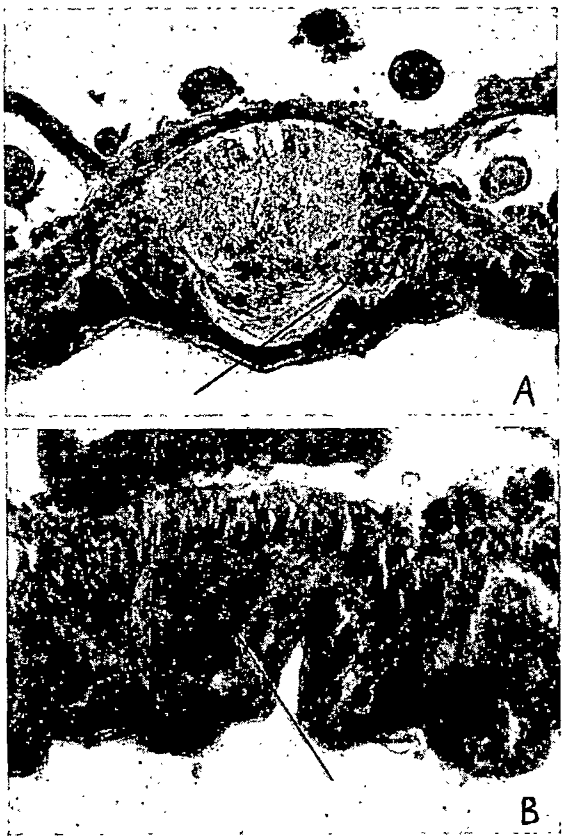

Fig. 1. *A*, transverse section through the nerve cord and surrounding tissues of *Arenicola claparedii*, showing two giant fibres (median, at the upper surface of the cord) and a giant cell (indicator line). *B*, sagittal section to show a giant cell. In each picture the length of the indicator line corresponds to 0·1 mm.

posed that Gamble and Ashworth sought the giant cells in sagittal sections cut through the main, fibrous part of the cord—a method that succeeds with any other species—their failure to detect the cells in *A. claparedii* can be explained; for sagittal sections must be cut to one side of the main mass of the cord if they are to pass through the giant cells in that species.

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Anti-brucella Phage

ANTI-BRUCELLA phage was discovered by the Russian workers Drozewkina[1] and Viershilova (private communication; 1956) who isolated it from manure and old cultures of *Brucella*. They demonstrated an influence of the phage on the dissociation of *Brucella* and suggested that mutation in *Brucella* was due to the action of the phage.

We have isolated fourteen brucella phages from our own collection of 200 strains of *Brucella* and compared them with the Russian phage with regard to (*a*) morphology, (*b*) influence on dissociation of *Brucella* and (*c*) their effect upon different types of *Brucella*.

Anti-brucella phage was searched for in old cultures of *Brucella brucei* in the following way. Small pieces of agar with the old brucella culture were added to new 6-hr. cultures of *Brucella brucei* *S*19 on Huddleson's liver medium. After 48 hr. in a thermostat and 24 hr. in a refrigerator, we removed a few drops of material and added them to new 6-hr. cultures of *Brucella brucei* *S*19.

This procedure was repeated ten times. Next, this material was filtered and treated with chloroform. It was then tested for phage on the standard strains of *Brucella* (*bovis*, *melitensis* and *suis*) on Braun's medium. In this way, we obtained phages, which were examined in the usual way for lytic titre.

Preparations for electron microscopy were obtained by centrifuging the cultures for 1 hr. at 18,000 r.p.m. They were shadowed with chromium.

Using the electron microscope (giving a magnification of 16,000) the phage appeared as a round elementary body, 60–80 mμ in diameter but with no tail. *Brucella* cells showed characteristic features of phage lysis (Fig. 1).

When phage begins to act on *S Brucella* colonies, a picture is obtained giving evidence of a process of dissociation into *R* and *I* forms. Using Braun's method[2], the radiating layers of *R* phase on the base of *S* colonies may be observed. This known type of colony described by Huddleson[3] appears, therefore, to arise from phage modification.

Using Henry's technique[4], we have also observed flat colonies with frayed margins around which numerous micro-colonies appeared, an observation also made by the Russian workers (ref. 1 and Viershilova, private communication; 1956). Another type of colony observed was the flat granular type.

The Russian phage did not lyse *Brucella melitensis* or *Br. suis* from our collection, neither did it have any effect on the *suis*-type strains received from Denmark, Czechoslovakia, America or the standard F.A.O. W.H.O. *suis* No. 1330. The Russian phage lysed typical *Br. abortus* strains (Fig. 2), but no lysis

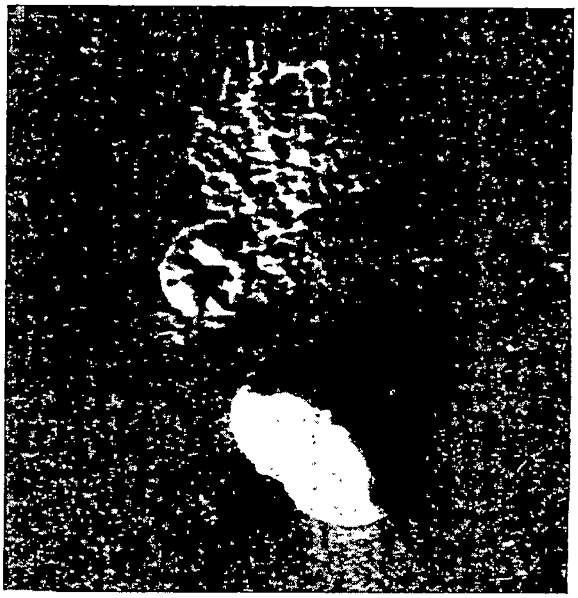

Fig. 1. *Brucella brucei* and phage. (× 16,000)

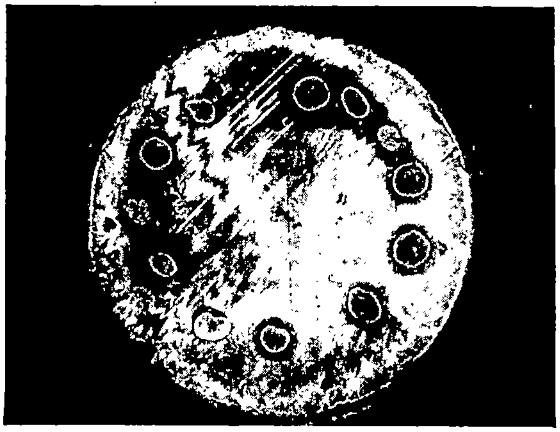

Fig. 2. *Brucella brucei* (*bovis* 544) and fourteen races of phage (−) → (+++)

occurred when atypical strains (for example, strains differing from the standard F.A.O. W.H.O. strain 544) were exposed to the action of the same phage. However, it was observed that the specific action of the phage on *Br. abortus* changed; this involved both the phages and the *Brucella* strains. The fourteen phages isolated by us did not lyse either *melitensis* or *suis* strains. Further investigations are in progress.

Work is proceeding on the phage typing of *Brucella* strains comparable to the phage typing of the salmonellas, shigellas and staphylococci.

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An Electron-Microscopic Study of the Ciliature of the Trochophore Larva

THE trochophore larvæ of marine polychæte worms present several ciliary structures convenient for comparative study.

From an electron microscopic study of the equatorial band (prototroch), which has a motor function, the following conclusions were drawn (figures in parenthesis refer to Figs. 1 and 2).

The structure of the external stem of the cilium as a ring of nine peripheral fibrils around a central fibril was confirmed (1).

At certain places the ciliary membrane, less dense and much thinner than the fibrils, encloses intraciliar swellings (2), apparently of ordinary cytoplasm. This ciliary membrane is continuous with the cellular one (3).

Before penetrating the cell, the cilia pass through pores in the cuticle, which consists of two layers (5 and 7) connected at several places (6). Between the cuticle and the outer cell membrane there is a large extracellular space (4) in which the cilia are connected with the segments arising from the basal bodies (8).

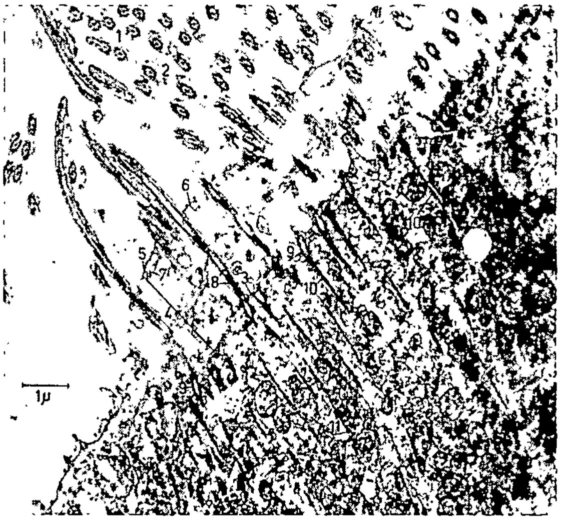

Fig. 1. Equatorial band of Trochophora (× 7,500). (1) Kinocilium, transverse section; (2) intracillar swelling; (3) cellular membrane; (4) extra-cellular space; (5) external layer of the exoplate; (6) connexion; (7) internal layer; (8) basal body; (9) basal body; (10) rootlet; (11) mitochondria

The basal bodies (9) are nearly symmetrical, hollow and somewhat swollen in the centre. The rootlet (10) seems to sprout from the basal bodies and has a periodic structure, with an interval of about 600 A. Numerous mitochondria (11) are found close to the rootlets, which become narrower toward the end.

A narrow slit occurs between the top of the basal body and the ring (above 8) in which the nine fibrils of the stem end. The central fibril stops above this ring. Another ring, with nine external bristles, looking like a cog-wheel, is formed by the nine fibrils while crossing the external structure described above. The name 'exoplate' is suggested for this external formation, which envelops the whole trochophore like a bag, stretched around the cilia, folded elsewhere. This bag finishes in the stomodæum, where it is replaced by microvilli, standing like a palisade between the bases of the endodermic cilia.

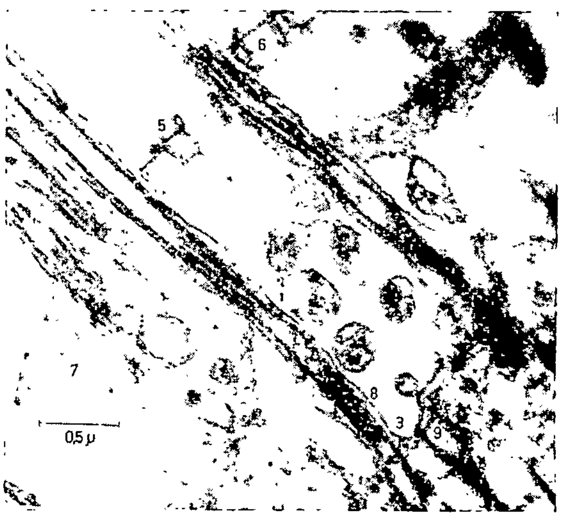

Fig. 2. Kino-cilia (part of Fig. 1) (× 30,000)

The trochophore larva shows a non-stop whirling motion in a spiral path through the fluid. The basal bodies, closely packed in the mid-line of the prototroch, form a semi-rigid structure, on which the cilia beat rhythmically. The beats result from contractions of the rootlets; during these contractions the outer part of the cell, under the ring of the basal bodies, is shortened. This compression acts on the hollow tube of the basal body, unfolding it and drawing the stem into a pendular motion.

The nine columns give rigidity to the stem, which can attain a length of 100μ for a diameter of 0·3μ. The exoplate ensures regularity in the spacings of the stems; its elasticity ensures the return of the cilia after movement. Hydrodynamic adjustment is made by continuous variation of the body's form: the looseness of the exoplate permits this under the control of the ciliary bands.

In slowing down, the whirling motion is neutralized by lateral bands of cilia, near the main moving band: in each cell the rootlets point in the same direction. Knowing how the equatorial band moves, we can deduce its function through the position of the cilia on the electron-micrographs, each cell being a functional unit.

A sagittal section of the main equatorial band (prototroch) reveals five different parts: the first and second decide the form of the animal; the third and fifth can, by fanning out, open and shut off the operating space of the fourth band, which forms the main motive organ.

A similar arrangement appears in the perianal band (telotroch), with a pars motoria working as a screw, and a pars plastica, over less compact cytoplasm, changing the form of the animal.

If we consider that the larva has to maintain a constant rhythm, each cell being sensitive to this pattern, the structures studied above explain how it is regulated. The role of the nerve is to give the tempo by a continuous wave of activation.

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Gibberellic Acid and Vernalization

Several workers[1,2] have reported that treatment with gibberellic acid induces early flowering in certain biennial plants in the same season and thus replaces their normal low-temperature requirement. In these biennial plants, extension growth and flowering go hand in hand, and it is quite likely that gibberellic acid replaces vernalization treatment incidentally, by bringing about the former, which is an almost universal action of the chemical. In the present investigation this suggestion has been tested by determining the effect of gibberellic acid on the flowering of both vernalized and normal plants of *Brassica campestris* L., *Cicer arietinum* L., *Linum usitatissimum* L. and *Lens esculanta* Moench, none of which has any obligatory low-temperature need for flowering. In *Brassica*, the reproductive process is associated with a change in the growth habit of the plant from that of rosette formation to stem elongation, while in the rest it is not so.

Treatments consisted of: (1) post- and pre-vernalization soaking and soaking of normal seeds for 8 hr. at the room temperature and (2) one or several sprayings to run-off, and dropping on the youngest leaf at the apex, at different stages of growth, of both vernalized and normal plants, 100, 25 and 1 p.p.m. aqueous solutions of gibberellic acid. Records of the average time taken from sowing to anthesis and of the number of leaves developed on the main axis before the appearance of the first flower bud were kept.

Leaves on the treated plants of *Cicer* and *Linum* developed slight chlorosis and on the former there was overcrowding in the apical region at an advanced age.

Spraying and dropping treatments with 100 and 25 p.p.m. of gibberellic acid brought about an extra growth in length in both vernalized and normal plants of *Cicer* and *Lens*, but there was scarcely any effect on *Linum*. In *Brassica*, an early elongation of the shoot was recorded only in the unvernalized plants, but there was barely any difference in the final height of the treated and untreated ones. Rudimentary flower buds could be detected in both normal and vernalized plants of *Brassica* as soon as the shoot started to elongate, but in the plants treated with gibberellic acid this is possible only when they attain a certain height. This confirms the findings of several workers[1–3]. Statistically significant earliness in flowering was obtained only in unvernalized plants of *Brassica* subjected to repeated applications of 100 p.p.m. of gibberellic acid (Table 1).

In the present investigation, seed treatments of all the four plants with gibberellic acid failed to produce any earliness in flowering; hence it may be concluded that this chemical does not replace 'vernalin'. Application of gibberellic acid to growing plants, too, is effective only in *Brassica*, but the degree of earliness induced is rather poor when compared with that resulting from chilling. Thus, for example, in the sowing of October 4, 1957, gibberellic acid treatment brings about an earliness in flowering of 8·0 days, and a reduction of 1·2 in the number of leaves; for plants raised from maximally vernalized seeds the corresponding figures were 23·1 days and 7·3.

Induction of early flowering is one of the many effects of vernalization. Among others, mention may be made of stem elongation in certain rosette-forming plants and several morphological changes, such as the shortening of the first leaf in winter wheat and rye, change in the shape and margin of the leaves in *Cichorium intybus* and a diminution in the length of the hypocotyl and area of the cotyledonary leaves

Table 1. Effect of a 100-p.p.m. Aqueous Solution of Gibberellic Acid on the Flowering of *Brassica campestris* L. Number of Plants are given in Brackets

Date of sowing	Mode of application	Time taken for anthesis in days		Leaf number	
		Gibberellic acid	Control	Gibberellic acid	Control
Aug. 24, 1957	5 sprays, one every 3 days, starting at an age of 5 days	52·5 (13)	60·8 (16)	16·1 (13)	18·1 (16)
Oct. 4, 1957	7 drops, one every 3 days, starting at an age of 7 days	50·8 (21)	58·8 (20)	16·0 (15)	17·2 (12)
Nov. 5, 1957	3 sprays, one a week, starting at an age of 7 days	65·1 (20)	71·5 (12)	14·9 (20)	16·9 (12)

in *Phaseolus radiatus*. In annual plants like *Cicer*, *Linum* and *Lens*, the early floral initiation is scarcely associated with an extra elongation of the stem of the type met with in the biennial plants. In the rosette-forming brussels sprouts, Verkerk[4] has demonstrated that stem elongation and flower initiation are two separate actions of the vernalization treatment. In gibberellic acid treatment also these two actions are separate, but a fundamental difference exists between the vernalization and gibberellic acid effects, as in the former, the flower buds become visible almost simultaneously with that of extension growth, while in the latter it is not so[2,3,5].

This investigation is further support[6] for Lang's suggestion that the primary effect of gibberellic acid is on stem growth, flower formation being brought about indirectly.

I am greatly indebted to Eli Lilly and Co. for the supply of gibberellic acid used in these experiments.

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Response of Cacao to Fertilizers

Cunningham and Lamb[1] have recently described an experiment in Ghana which demonstrated the response of cacao to fertilizers both with and without shade. These results serve to confirm more intensive studies, made at the Imperial College of Tropical Agriculture in recent years, which have resulted in the development of a general theory of the interaction of shade and nutrition in the growth and cropping of young cacao.

A statistically designed field experiment was planted using an artificial shade of slats to let through different percentages of full sunlight. Each shade treatment carried a 2 × 2 × 2 factorial nitrogen–phosphorus–potassium layout with the fertilizers present or absent. Clonal cuttings were used as planting material.

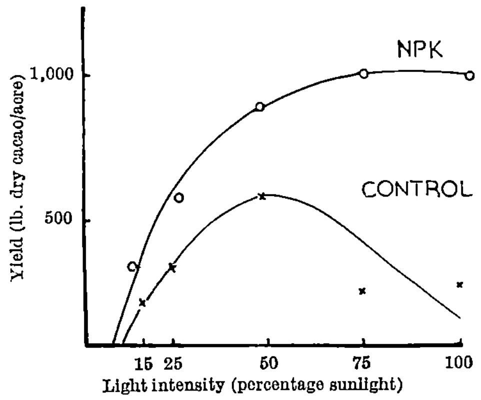

Fig. 1. Relation of yield (lb. dry cacao/acre) to light intensity for control and fertilizer plots

The yields at three years of age for the control and fertilizer plots are shown in Fig. 1. From this it is clear that with light intensities less than some 50 per cent of full light, light is limiting to yield. At more than 50 per cent light, however, the drop in yield of the control plots as compared with the increasing yield of the fertilizer plots indicates that nutrition is now limiting to yield. The results have been described in detail by Evans and Murray[2] and by Murray[3], together with the effects of shade removal and such changes in leaf analysis as occur under different shade conditions.

It is obviously impossible to consider either the shade or the nutritional requirements of cacao independently. In addition, the relationship is dynamic, varying with increasing size of tree and consequent self-shading. This interaction of light intensity with the nutritional status of the tree is of great importance in the agronomy of the crop.

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Yield Variations in Tree Crop Experiments with Specific Reference to Cacao

In the past, large yield fluctuations within treatments in cacao fertilizer experiments have proved difficult to understand. These fluctuations, frequently occurring between adjacent trees, necessitate an unwieldy degree of replication before a sensible level of error variance is obtained within the experimental area. It is important to know the cause of these fluctuations, not only to reduce to a minimum the acreage required for field-experimentation with cacao but also to help in understanding the behaviour of tree crops and of cacao in particular.

Results from the long-term fertilizer trials on cacao conducted by this Department[1] have now shed some light on this problem. Thus in Fig. 1 mean cacao yields of *ICS* 1 clones obtained during the sixth, seventh and eighth years since these trials were planted, have been plotted against tree girths at 3½ years of age. The degree of correlation between these two factors was highly significant (at $P = 0{\cdot}001$ level).

It is clear from this relationship that, so far, the yielding capacity of the trees and the variation in yield have been largely determined by uncontrolled variables operative during the first few years following the establishment of the experiment. The effect of these variables was reflected in the varying measurements of girth at 3½ years of age. It is suggested that these variables are associated with traditional methods of cacao establishment.

Traditionally, young cacao is permitted a heavy degree of ground shade while its root system is attaining vigour. This is sensible, except that in practice these conditions deteriorate into heavy bush encroachment. In cacao-growing areas where there is a marked dry season—as in Trinidad—this inevitably means intense competition for soil moisture as well as nutrients. If weed competition and soil

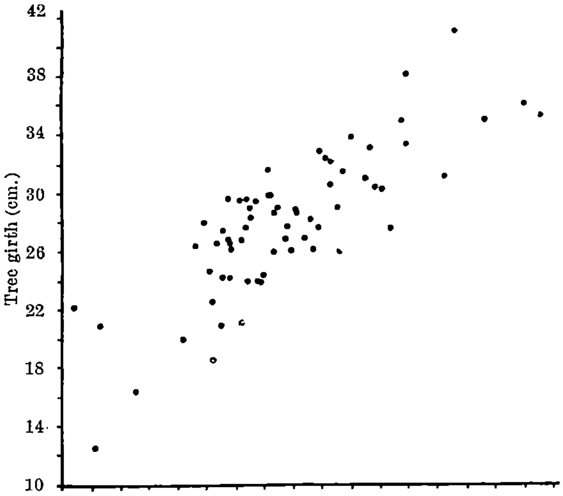

Fig. 1. Cacao tree size/yield correlation ($r = 0{\cdot}810$: for $P = 0{\cdot}001$ $r = 0{\cdot}380$)

moisture deficits are not controlled during the early stages of establishment—and Fig. 1 suggests that young cacao is particularly sensitive to adverse factors in its environment—then extreme variability in yield can be expected later.

Fig. 1 implies that traditional procedure is infringing a fundamental principle of plant science. This principle simply contends that a check to development in plants is permanent and cannot be rectified by later attempts at amelioration. The same principle has also been recognized to a restricted extent in animal studies[2], and its general acceptance lays emphasis on good management for precise control of field experiments. It has, too, equally relevant practical importance in good farming and successful agriculture.

From the point of view of plant science, it raises a critical issue in the measurement of fertilizer response. If the evaluation of fertilizer response at a given site is to be scientifically unimpeachable, then environmental effects—and the word environment is used in its fullest implication—must all operate in the direction of improved plant-growth. The net effect on plant-growth of all individual environmental effects is the algebraic sum of those effects. If any single effect is unintentionally given a negative sign, limitations to growth will be other than those intentionally imposed within the limits of the statistical layout used. The arithmetical order of an environmental factor with a negative sign may completely swamp response to a fertilizer. This has certainly been the case in many fertilizer experiments on cacao in the past.

A full account of this work will be reported elsewhere.

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The Macronucleus of *Spirostomum*

The purpose of this communication is to describ an interesting property of the macronucleus of species of *Spirostomum*, a large freshwater ciliate The nuclear apparatus of this animal consists of long cylindrical macronucleus and a number of smal micronuclei. The cytology of this species has bee described by Seshachar and Padmavathi[1]. Feulge preparations show a number of granules of varyin sizes in the macronucleus embedded in a more homogeneous matrix.

During certain regeneration experiments in thi laboratory, it was noticed that the macronucleus i highly extensile and could be stretched to a grea length. An easy and simple method was to hold on end of the animal down on a slide and pull the othe end with a needle. The body ruptures, but th macronucleus can be pulled out until a long, thi strand results. A number of such attempts wer made and were almost always successful, and severa macronuclei pulled to varying lengths were obtained They were then fixed and stained with Feulgen Fig. 1 shows: (*a*) the normal macronuclei of th vegetative animal, and (*b*) a nucleus partiall stretched. One macronucleus was pulled to such length that five separate photographs had to b taken to include the whole. [This photograph wa too long for reproduction on the same scale as th others.—Editors.] The maximum length to whic a 0·18-mm. macronucleus could be pulled out wa nearly 2·72 mm., which is more than fifteen time the original. Further stretching almost alway resulted in its snapping.

Similar observations were made on another species, *S. ambiguum*. In this species, the macronucleus i moniliform, with clear swellings and slender connexions between them. When stretched, the lengthening occurs at the expense of the swellings an the resulting body is a greatly elongated unifor strand.

This is probably the first record of the nucleus o any animal cell displaying such remarkable extensil properties. Recent examination with the electro

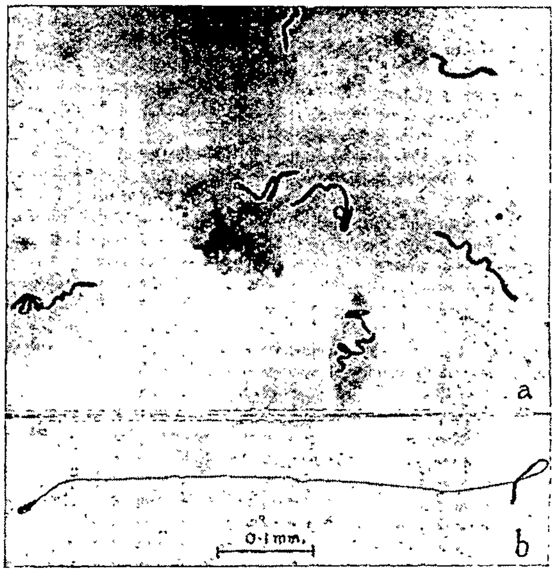

Fig. 1. Photographs of Feulgen preparations of the macronucleus of *Spirostomum* sp. (*a*) Nucleus of normal vegetative animal; (*b*) nucleus partially stretched

microscope has shown that the ciliate macronucleus, like the nucleus of other more typical cells, possesses a double membrane with perforations[2]. The amphibian oocyte nucleus, which was among the first to be examined with the electron microscope[3], has a membrane which readily ruptures under the slightest pressure and is presumably different from that of the macronucleus, which must have remarkable powers of resistance to mechanical manipulation and great extensile properties. It would be interesting to see how the nuclear membrane is accommodated to the stretching possible in *Spirostomum*. That a bounding membrane exists, even in this maximum stretched state, seems beyond doubt.

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Embryology of *Atkinsonia ligustrina* (A. Cunn. ex F. Muell.) F. Muell.

The embryology of *Atkinsonia ligustrina*, a root parasite of the Loranthaceae[1] endemic to Australia, has so far remained uninvestigated. The present account is based on a study of some specimens of this plant kindly sent by Prof. H. S. Mckee of the University of Sydney.

The first important point arising from this work concerns the nature of the calyculus. In the Loranthaceae this is generally devoid of a vascular supply, and its morphological nature has consequently been much debated. Roxburgh[2] and Bentham and Hooker[3] considered it to be a true calyx and Danser[4] conceded the same "on practical grounds". On the other hand, Eichler[5] considered it to be an axial structure, and this view was supported by Engler and Prantl[6] and by Schaeppi and Steindl[7]. Narayana's[8] report concerning the presence of vascular bundles in the seven-toothed calyculus of *Nuytsia floribunda* supports Bentham and Hooker's view of the sepaline nature of the calyculus. The feeble vasculature in the calyculus of *Atkinsonia* (Figs. 1 and 2) appears to be a connecting link between *Nuytsia* and the other Loranthaceae in which the calyculus is devoid of a vascular tissue.

Atkinsonia also differs from most other Loranthaceae in having spherical pollen grains (Fig. 3). The only other plant of the family which shows a similar condition is *Tupeia antarctica*[9,10].

In the development of the embryo sac a six-nucleate stage (two nuclei in the upper end of the gametophyte and four in the lower) precedes the usual eight-nucleate condition. The four nuclei at the upper end give rise to the egg apparatus and the upper polar nucleus. Three out of four nuclei at the lower end organize themselves quite early into the antipodal cells, whereas the fourth functions as the lower polar nucleus. As in *Macrosolen*[11], the lower end extends downward leaving behind the antipodals *in situ*. The upper ends of the embryo sacs extend to the base of the style and often show one or two small apical extensions, which probably have a haustorial function.

The fusion of the polar nuclei always takes place below the egg. The first division of the zygote is vertical and subsequent divisions are transverse, resulting in a biseriate pro-embryo. Due to the elongation of the suspensor, the embryo is pushed downward into the collenchymatous tube (Fig. 4). The endosperm is cellular and, as in other Loranthaceae, the endosperms of all the embryo sacs unite to form a composite structure with eight deep lobes in the mature fruit.

The pericarp comprises the outer leathery coat followed by the viscid layer, a zone of several layers of sclerotic cells, and the crushed vascular tissue (Fig. 5). The sclerotic zone, which is responsible for the drupaceous nature of the fruit, is uncommon in the Loranthaceae.

Our knowledge of the subtribe Gaiadendrinae, which includes only two genera—*Atkinsonia* and

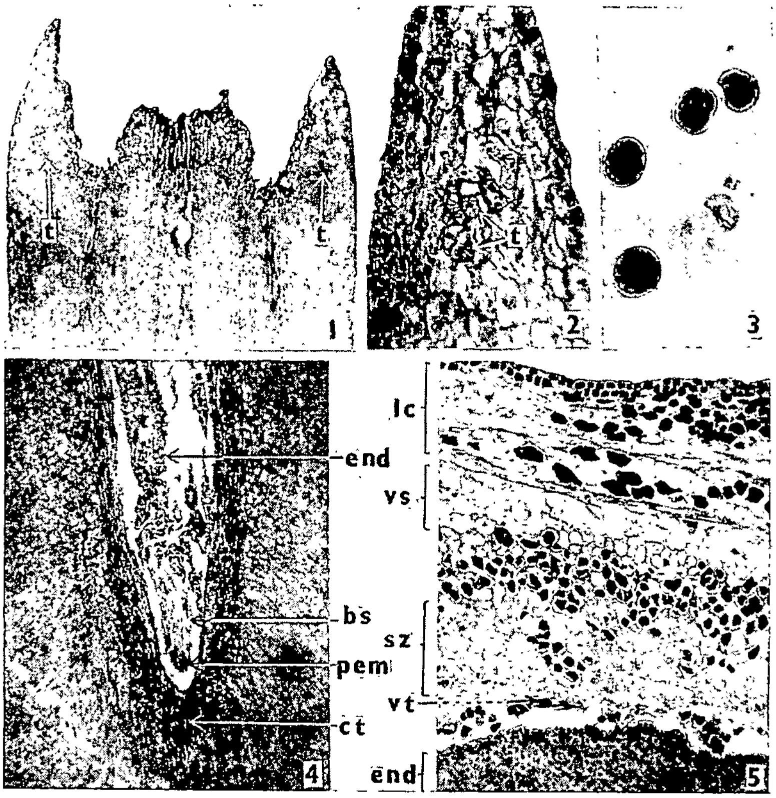

Fig. 1. Long. section of the upper part of ovary showing tracheids in the calyculus (× 33). Fig. 2. Magnified view of tracheids (× 8). Fig. 3. Pollen grains (× 126). Fig. 4. Part of ovary showing the pro-embryo with a broad suspensor (× 37). Fig. 5. Portion of pericarp (× 30). (Key: *bs*, broad suspensor; *ct*, collenchymatous tube; *end*, endosperm; *lc*, leathery coat; *sz*, sclerotic zone; *t*, tracheids; *vs*, viscid layer; *vt*, vascular tissue)

Gaiadendron—is very meagre, and it is likely that *Gaiadendron* may also show some interesting points.

The spherical shape of the pollen grains and drupaceous nature of the fruit suggest a close relationship between the Loranthaceae and the Santalaceae.

In recent years the embryology of many members of the Santalaceae (*Comandra, Exocarpus, Leptomeria, Mida. Osyris, Santalum* and *Thesium*) and Loranthaceae (*Amyema, Barathranthus, Helicanthes, Lepeostegeres, Lysiana, Macrosolen, Nuytsia, Peraxilla, Tapinanthus, Tapinostemma, Taxillus* and *Tolypanthus*) has been studied in this Department. It would be greatly appreciated if fellow botanists will help in procuring specimens of *Buckleya, Choretrum, Fusanus, Myoschilos, Nestronia, Omphacomeria* and *Pyrularia* of the Santalaceae, and *Aëtanthus, Diplatia, Gaiadendron, Hyphear, Psittacanthus* and *Tupeia* of the Loranthaceae.

I wish to thank Dr. B. M. Johri and Prof. P. Maheshwari for valuable suggestions and comments.

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Purification and Serology of Cucumber Mosaic Virus

CUCUMBER mosaic virus causes many important plant diseases and occurs as a group of strains differing in their host-range, symptoms produced, transmissibility and other properties. Few studies have been reported on the serological relationships among these strains, possibly because of their labile nature *in vitro* and their low concentration in the host plant. In crude host extracts the virus becomes non-infectious when stored for a few days or when diluted to approximately 10^{-3}. The strain relationships have been studied previously by cross-protection tests. Although antisera to cucumber mosaic virus[1,2] have been claimed, later attempts[3] were unsuccessful. Antisera of low titre have been obtained to tomato aspermy[4,5], a virus related to cucumber mosaic virus.

A strain of cucumber mosaic virus previously described[6] has now been partially purified and used to produce an antiserum. The purification procedure was as follows. The virus was cultured in leaves of tobacco plants (*Nicotiana tabacum* L. var. Havana 425) mechanically inoculated with sap of corollas from infected cucumber plants. Inoculated plants were grown at 24–30° C. in a glasshouse from May until October. The inoculated leaves were harvested, the mid-veins removed and the tissue homogenized at 3° C. in 0·5 *M* potassium phosphate buffer (*p*H 7·5) containing 0·1 per cent thioglycollic acid (1·25 ml. of buffer for each 1·0 gm. of leaf tissue). The homogenate was squeezed through a glass-wool pad and *n*-butanol was added dropwise to the constantly stirred filtrate to give a concentration of 8·5 per cent. The mixture was stirred for a further 30 min. during which time the chloroplastic material was precipitated. The precipitate was separated by centrifuging at 5,000 r.p.m. for 10 min. and the clear, amber-coloured supernatant was filtered through glass-wool. The virus was sedimented by centrifuging the filtrate at 30,000 r.p.m. for 2 hr. in a No. 30 rotor of a 'Spinco' model *L* ultracentrifuge. After ultracentrifugation the supernatant was discarded, the centrifuge tubes drained and the pellet in each tube dispersed in 0·5 ml. of 0·05 *M* potassium phosphate buffer at *p*H 7·5. Resuspension of the virus was continued by mechanical shaking for 2 hr., after which the suspension was clarified by centrifugation at 5,000 r.p.m. for 10 min. The faintly opalescent supernatant containing the virus was carefully withdrawn.

The virus preparations were assayed for infectivity by inoculating the young, expanding primary leaves of cowpea (*Vigna sinensis* Endl. var. Black) on which necrotic local lesions developed, usually within 24 hr. The dilution end-point of the virus in these preparations varied from 10^{-3} to 10^{-6} when diluted in 0·05 *M* buffer. The longevity of the virus in these preparations was greater than that generally reported[7]; one preparation was infectious after 45 days when stored at 3° C. The infectivity in this case, however, was about one-half of that of the freshly purified virus.

Rabbits were injected intravenously at four to five day intervals with 4 ml. of virus prepared as described. Injections were repeated six times and the rabbits were bled six days after the last injection. When the rabbit serum was used for precipitin tests with the virus, a positive reaction was obtained at serum dilutions up to 1/1024.

Cucumber mosaic virus, purified as described, was prepared in various ways for electron microscopy and compared with similarly treated control preparations from healthy tobacco leaves. Samples were sprayed on to collodion-coated electron microscope grids and allowed to air dry. The specimens were shadowed with uranium. When examined with an *RCA* type electron microscope, the grids sprayed with the virus preparations showed numerous, uniform spheres with a mean diameter of 40 mμ. These spheres were not found on grids sprayed with the control preparations. These observations are in agreement with previous work[6] on the shape of cucumber mosaic virus.

Full details of this work will be published later. We wish to express our thanks to Dr. P. Kaesberg, Mr. Bockstahler and Mrs. Sachs of the Department of Biochemistry, University of Wisconsin, for the assistance given with the electron microscope studies.

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Observations on the Spread of Mouse Polyoma Virus Infection

The tissue culture growth of the mouse parotid tumour virus, referred to by Stewart *et al.*[1] as "SE polyoma virus", has led to the development of rapid methods for its demonstration and determination, and to practical and specific serological techniques for antibody determinations as well[1-5]. We have made preliminary observations on the distribution of antibodies in various mouse colonies and on the excretion of virus.

Uninoculated mice of six breeder colonies were bled individually, and the sera tested for complement fixing and hæmagglutination inhibiting antibodies, the latter test using 16 hæmagglutinating units. Close correlation was found between the two tests[6]. Hæmagglutination inhibitory antibody at 1 : 200 or greater, or at 1 : 100 in serum treated with receptor-destroying enzyme of *V. cholera*, was considered positive. Table 1 summarizes the frequency with which antibody was detected in mice of the various colonies. Three colonies appeared completely free of infection, while the others had infection in almost all strains tested. Antibody was found predominantly in mice more than three months of age. No evidence of strain specificity of infection was observed; for example, adult *AKR* mice had infection-rates ranging from 5 to 100 per cent in the three infected colonies, while none of 84 adult *AKR* mice in the Jay–Poiley colony was positive.

Table 1. INCIDENCE OF ANTIBODY TO POLYOMA VIRUS IN SIX MOUSE COLONIES

Colony	No. of of mice positive/No. tested		No. of strains or sublines positive/No. tested
	1–3 months old	>3 months old	
Andervont (N.I.H.)		0/95	0/4
Gross (New York)	1/61 (2 per cent)	49/58 (84 per cent)	4/5
Jackson Memorial Laboratory (Bar Harbor)	1/53 (2 per cent)	5/85 (6 per cent)	3/4
Jay–Poiley (N.I.H.)	0/539	0/536	0/19
Law (N.I.H.)	5/120 (4 per cent)	149/406 (37 per cent)	15/16
Microbiological Associates (Bethesda)		0/62	0/3

It is probably significant that two of the three ıegative colonies are maintained in separate quarters ınd by personnel who do not handle experimental nice, while the three infected colonies are located)hysically in proximity to experimental colonies and vork with polyoma virus and mouse leukæmias, and ıre cared for by the same personnel. In the Law :olony, antibody-rates in uninoculated mice 6–11 nonths old were 59 per cent (36/61) in mice in the 'oom with new-born mice inoculated with polyoma 'irus, 39 per cent (36/92) in the room with adults vhich received the virus as new-borns, and 13 per cent 13/101) in a room which does not house animals noculated with virus. Also, mice brought into our aboratory from the Jay–Poiley colony as new-borns nd inoculated with uninfected control tissue culture luids have become antibody positive after 4–6 months n about 30 per cent of individuals tested.

In the Law colony, serological conversions in mice e-bled after 2–4 months were somewhat more requent in mice one to five months of age when bled iitially (19 of 48 converted) than in mice more than x months old (12 of 47 converted).

To determine the source of the apparent environmental contamination, the following tests for virus were made. Urine and mouth swabs were taken from 8 mice which had been inoculated with virus as new-borns five to ten weeks previously; these mice were in five different cages, and the bedding and drinking water of each cage were also sampled. The virus detection procedure employed was based on the production of antibody in adult mice inoculated intraperitoneally (mouse antibody production test): this procedure has been found to be highly sensitive for detection of virus[6]. A suspension of the material tested was inoculated intraperitoneally into three weanling mice from the Jay-Poiley colony, and three weeks later their sera were tested for hæmagglutination-inhibiting antibody. 84 control mice inoculated with saline were distributed in the jars with the test mice, and none developed antibody. Seven of the eight urine specimens were positive for virus, as were all eight mouth swabs, all five bedding samples, and four of the five drinking bottles.

Inhalation may be the means of entry, since we have found that mice can be infected as new-borns or adults by intranasal instillation of 10^2 to 10^3 intraperitoneal immunizing doses, but as yet we have not been able to infect by feeding.

These results suggest that environmental contamination is important in the spread of polyoma virus, and that cross-infection is to be expected in laboratories working with the agent. The implication that infection is generally acquired at several months of age would explain the rarity of spontaneous occurrence of the characteristic parotid tumours, even in infected colonies[7,8], since, experimentally, tumours can be produced only by inoculation of suckling mice. The great variation in polyoma infection-rates in various *AKR* stocks indicates that polyoma virus bears no etiological relation to spontaneous *AKR* leukæmia, despite their repeated association[8], since high leukæmia-rates are found in all *AKR* stocks.

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Biochemical Changes in Virus-infected and Regenerating Mouse Liver

The biochemical changes accompanying the multiplication of an animal virus within its host cell are still largely unknown. Alterations in the levels of activity of a variety of enzymes in mouse brain infected with virus have been reported by Bauer[1].

Table 1

Enzyme	Activity ± standard error in livers			
	Normal	Infected 24 hr.	Regenerating 48 hr.	Infected 20 hr., regenerating 48 hr.
Succinic dehydrogenase	6·38 ± 0·28	8·52 ± 0·33	6·52 ± 0·44	6·34 ± 0·46
Xanthine dehydrogenase	1·39 ± 0·05	2·70 ± 0·11	2·33 ± 0·11	2·49 ± 0·28
Uricase	216 ± 16	283 ± 23	182 ± 30	185 ± 26
Acid phosphatase	69·9 ± 2·7	65·4 ± 6·6	80·4 ± 12·6	46·7 ± 2·38

In this system the number of infected cells is not known and the variety of cell types and possibility of compensatory changes in other neurones make interpretation difficult. Tissue cultures infected with poliovirus show marked changes in various enzyme activities[2], but here the considerable variation in physiological state of the culture produced by small experimental variations must be borne in mind when interpreting results. The effects of a virus on the cells of its natural mammalian host can be studied conveniently in the livers of mice infected with large (10^9–10^{10} *LD*50) intravenous inocula of ectromelia virus[3]. Simultaneous infection of almost all hepatic parenchymal cells takes place, there is no cellular infiltration, and up to 30 hr. after infection there is little or no necrosis. Mouse livers so infected show a progressive increase in size without cell division. The comparison between normal growth in regeneration and that induced by infection, of either normal or regenerating liver, is of some interest. In liver regenerating after partial hepatectomy increase in cell size is followed by cell division, but in regenerating liver infected with ectromelia mitosis is inhibited[4]. Other evidence for nuclear changes is decreased synthesis[5] of coenzyme I and decreased adenosine deaminase activity in both infected and regenerating livers.

There is, however, no evidence to date of synthesis of ectromelia virus by the nucleus. The effects of infection and regeneration on some cytoplasmic enzymes (succinic and xanthine dehydrogenases, uricase and acid phosphatase) have been measured. Activities (per gm. fat-free dry weight) are expressed as μmoles substrate destroyed per minute (dehydrogenases), μgm. uric acid destroyed per minute (uricase) or King Armstrong units (acid phosphatase) (Table 1).

The activity of the succinic dehydrogenase complex is an index of the mitochondrial content of a tissue. There is no change in succinic dehydrogenase activity in regenerating or infected regenerating livers. Since the fat-free dry weight of the regenerating liver fragment has increased by 40 per cent, this represents a synthesis of mitochrondria proportional to liver growth, even though in the latter case cell numbers are not restored. The increase in activity in infected intact livers, which also show cell growth, represents a more than proportional increase in the mitochondrial population of each cell.

Xanthine dehydrogenase activity, localized in the soluble fraction, is increased in both regenerating and infected livers. By its aldehyde oxidase activity[6] this enzyme may play a part in the metabolism of 2-carbon fragments. This would seem more likely than the alternative suggestion that purine catabolizing activity is causally related to increased nucleic acid synthesis.

Uricase activity is wholly, and acid phosphatase activity partly, associated with the lysosome fraction of the cytoplasm[7]. Changes in activity in regenerating livers are not significant. In infected livers uricase activity is increased while phosphatase is littl changed before 24 hr. In infected regenerating liver uricase activity does not differ from that of uninfected controls, while phosphatase activity fall markedly. These findings suggest a considerabl alteration in the composition of some subcellula fractions. Uricase/acid phosphatase ratios wer determined on three centrifugally separated fraction of the cytoplasm: heavy mitochondria, light mitochondria (including lysosomes) and a supernatan (including microsomes)[7]. The results (expressed i arbitrary units) are shown in Table 2. These finding may be due to either (*a*) changes in the enzymi composition of all members of a particle populatio which is otherwise little altered; or (*b*) selectiv damage to some members of a population in whic enzyme activity is unequally distributed.

Table 2

Cytoplasmic fraction	Uricase/acid phosphatase ratios in livers		
	Normal	Infected 24 hr.	Regenerating 48 hr.
Heavy mitochondria	7·9	5·9	8·1
Light mitochondria	9·0	10·0	8·8
Supernatant	3·4	1·5	2·8

Marked biochemical changes are induced in th cytoplasm by both infection and regeneration. Cel growth in regeneration may be considered to b normal and orderly, while that in infection is disorderly to the extent that it ultimately results in cel death. This disorder is reflected in difference between some of the changes in infected and regenerating livers. The mechanism of production of th changes in cells infected with virus is still obscure They may be a direct result of the presence of viru or virus components in the cell; or they may be secondary response to a change in emphasis of metabolic pathways, produced during the early stages o infection. Studies of the effect of shorter periods o infection may help solve this problem.

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Oct. 1.

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Mutations in L-Forms

Conversion of bacteria into L-forms involves changes in physiology as well as morphology. Comparing sensitivity to drugs of L-forms and bacteria, we are struck by the much higher resistance of the former to penicillin. Strains of L-forms of *Proteus* used in our laboratory are able to grow in the presence of 60,000 units penicillin/ml. On the other hand, they are more sensitive to streptomycin, chlortetracycline and chloramphenicol than are the bacterial forms. Tulasne and Minck[1] found that stable L-forms of *P. morganii* were 8,000 times and unstable L-forms of *P. vulgaris* were 25,000 times more sensitive than the corresponding bacterial forms. Lederberg and St. Clair[2] showed a fifty-fold decrease in resistance to streptomycin after converting *Escherichia coli* to the L-form. The authors suggest that "this can be viewed as the negation of the S^R effect when the wall is stripped or a mutual reinforcement of penicillin and streptomycin in respect to another target". They were inclined to accept the former interpretation. Horoszewicz and Horoszewicz[3] noted the inhibitory action of streptomycin on the conversion of *P. mirabilis* to the L-form. In the presence of the antibiotic it was necessary to inoculate 1,800 times more bacteria to obtain the same number of L-colonies.

We have used a stable L-form of *Proteus mirabilis* subcultured more than 100 times on serum-agar and then adapted to charcoal-agar and lately to charcoal-broth[4]. Growth of L-forms in the charcoal media was much more luxuriant than in serum media. In charcoal-broth in 2–3 days, L-organisms formed a remarkable turbidity and some days later a thick, greyish pellicle which could be dispersed on shaking. Usually the number of L-colonies grown from 1 ml. of fluid medium was 2–4 × 10^8. Such dense fluid culture was suitable for study of the formation of antibiotic-resistant mutants. Our bacterial strain was inhibited by 10 units streptomycin/ml. while the stabilized L-form was sensitive to 0·0001 unit/ml. For antibiotic sensitivity tests, between 100 and 1,000 organisms were used per plate. To obtain mutants resistant to streptomycin we used 4–10-day old cultures of L-forms in charcoal-broth and added an equal volume of charcoal-broth with streptomycin. It was found that the time and frequency of mutation depended on the number of organisms in the culture. When the total number of L-form particles was 10^{11}, organisms resistant to 500 units streptomycin/ml. soon appeared. In 10 per cent of the flasks containing about 10^9 organisms, mutants resistant to 50 units/ml. appeared first, but after 5 days it was possible to isolate mutants insensitive to 500 units/ml. We did not succeed in isolating mutants resistant to 500 units/ml. from populations of only 3–4 × 10^7. Subculturing resistant strains on media with or without streptomycin caused no change in the character of the resistance to antibiotics.

We have also examined the streptomycin sensitivity of unstable L-forms derived from four strains of *Proteus mirabilis* and from their streptomycin-resistant mutants. L-forms obtained from S^R bacteria showed higher resistance than those from S^S organisms. Unstable L-forms derived from streptomycin-resistant bacteria could grow in the presence of 500 units streptomycin/ml., but we noticed that on charcoal-agar containing streptomycin but without penicillin the reversion from L-form to bacterial form was greatly delayed in comparison with that on charcoal-agar without either antibiotic. However, after ten subcultures, the time of reversion became independent of the presence or absence of streptomycin.

L-forms insensitive to 200 units chloramphenicol/ml., obtained by selection, did not show persistent resistance—usually after five or more passages on the medium containing chloramphenicol the culture was completely inhibited.

It was not possible to obtain antibiotic-resistant mutants by ultra-violet irradiation.

Our preliminary investigations suggest that mutants resistant to streptomycin can appear in L-form populations. It has been possible by selection to obtain mutants even more resistant to streptomycin than their corresponding bacterial forms. Probably the highly resistant mutants are formed stepwise rather than as one-step mutants.

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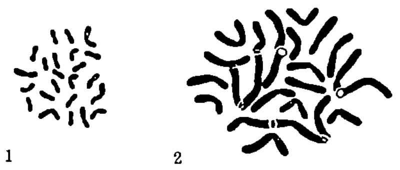
Somatic Chromosomes of *Leptaspis* and *Streptogyna* (Poaceae)

Both *Leptaspis* and *Streptogyna* represent very interesting groups from the point of view of the phylogeny of the Poaceae as their external morphology is very primitive. I collected *Leptaspis cochleata* Thw. and *Streptogyna crinita* Beauv. in woods at Dulva Kanda (about 4,000 ft.) in Ceylon while I was there in 1957. The root tips of the two species were fixed with Navashin solution at the habitats and, after my return to Japan, dehydrated and embedded in paraffin. Sections were cut at 15μ and stained by Newton's gentian violet method. Two individuals of *S. crinita* and one individual of *L. cochleata* were used for chromosome observation. As shown in Figs. 1 and 2, both species had $2n = 24$. The chromosomes of *L. cochleata* are clearly larger than those of *S. crinita*.



Figs. 1 and 2. Somatic chromosomes. (1) *Streptogyna crinita*. (2) *Leptaspis cochleata*. × 2,000

Leptaspis is characterized by the diclinous spikelets and belongs to the Olyreae. The tribe, which has never been examined cytologically, is distributed in the tropics, the majority of species being concentrated in Central America and the West Indies. From anatomical investigations of leaf and embryo, as well as morphological studies, the Olyreae are assumed to be distantly related to the Bambuseae. A number of Bambuseae species examined cytologically up to now have had $2n = 48$ or 72, suggesting the basic chromosome number of 12, whereas a few have $2n = 36$ or 54. *Leptaspis cochleata* is similar to the Bambuseae in the basic chromosome number, but the chromosomes of *Leptaspis* are somewhat larger.

Streptogyna has been referred to an independent tribe, Streptogyneae, by C. E. Hubbard[1]. The genus includes two closely related species which inhabit the tropics. *Streptogyna* had been traditionally treated as a member of the Centotheceae or Festuceae, but the leaf structure of the genus apparently indicates a relationship with the Bambuseae[2]. Streptogyneae and Bambuseae also share some common features in external morphology; for example, in respect to the lodicules the two groups are closely related. Also the chromosomal features of *Streptogyna*, clarified for the first time by the present observation ($b = 12$ and small chromosome sizes), are similar to those of the Bambuseae.

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Transformation of a Monochlamydius into a Dichlamydius Chimæra by X-ray Treatment

ACCORDING to Asseyeva[1], X-ray treatment of potatoes is "a powerful and reliable means of transforming monochlamydes into dichlamydes". No details of the treatment used are given in this paper, nor do any appear to have been published in a later paper. It is therefore of some interest to report an X-ray treatment that has given a successful transformation for the potato variety Red King, particularly as similar treatments might also work with periclinal chimæras in plants other than potatoes.

Red King arose as a 'bud sport' in the variety King Edward. It has tubers which are full pink (the pigment is in the periderm, which in potato tubers originates nearly entirely from the epidermis) except for small white patches at the heel end and beneath some of the eyes, whereas King Edward has tubers which are white with pink splashes around the eyes. The occurrence of the small white patches suggests that Red King is a periclinal chimæra in which only layer I has changed, layer II being still King Edward. This is confirmed by the fact that it gives hybrid progenies similar to those from King Edward itself (Table 2), and by the recovery of King Edward type tubers from both eye-excision and X-ray experiments (Table 1).

The results of an X-ray experiment using Red King are given in Table 1. Rose ends of tubers (about 1·5 cm. thick) with small sprouts (about 4 mm. long) were X-rayed by the Department of Radiotherapeutics, University of Cambridge, using a 200-kV. 'Maximar' X-ray machine, run at 15 m.amp. The different dosages were given by exposing them for 6, 7, 8 and 9 min. at 6·75 cm. from the aluminium filter. The highest dosage was lethal to all the sprouts on the treated rose ends. The plants grown from the rose ends receiving lower dosages produced tubers of a number of types, and they included one plant which had tubers of the Red King type but without the small white areas. This is the type to be expected where both layer I and layer II are Red King, and that this was so is confirmed by the breeding results (Table 2)—thus, in contrast to the seedlings from King Edward and normal Red King, the seedlings with coloured tubers in its progeny have full colour and not white with coloured splashes.

Table 1

X-ray dosage (r.)	No. of rose ends treated	No. of rose ends producing plants	No. of plants with tubers of types:					
			Full pink	Red King	Red King plus King Edward	Intermediate Red King–King Edward	King Edward plus white	White
4,500	4	0	—	—	—	—	—	—
4,000	4	3	0	2	0	0	1	0
3,500	4	3	1	0	1	0	0	1
3,000	4	4	0	2	0	1	1	0

Table 2

Parents of cross	No. of plants with tubers of types		
	Full colour	White splashed colour	White
King Edward × white	0	7	12
Red King × white	0	11	19
Full pink from X-rayed Red King × white	5	0	6

The other types of tubers produced by the X-rayed plants have not been studied fully. It should, however, be noted that the plants with white tubers were expected since similar tubers are found in eye-excision experiments with King Edward, Red King and even with white-splashed-colour type seedlings bred from King Edward (ref. 1 and Howard, unpublished work).

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Gene Control of Specificity and Activity: Loss by Mutation and Restoration by Complementation

THE *S* gene, controlling the incompatibility reaction between pollen and styles in plants, exists in a very large number of 'alleles', each producing a characteristic antigen in the pollen and a similar antigen with the same specific activity in the style, through which the pollen tube must grow to achieve fertilization. Mutations and recombination of this gene in *Oenothera organensis*, selected out of 10^9 genes, have been of one type only[1]. The chief feature about these mutant *S* alleles is their complete loss of activity in the pollen, so that no active antigen could be detected by the sensitive pollen-style tests. The favoured[2] interpretation was that one part or area of the gene was determining specificity and another area determining a carrier responsible for the activity in pollen and style. The mutant change would then be some defect in the activity-determining area of the gene. With this interpretation it must be concluded that none of the mutants gave an active and changed specificity but only a loss of activity.

The results, however, did not entirely exclude an interpretation based upon two genic areas that determine specificity, one for the pollen and the other for the style. A mutation to a changed specificity in the pollen, unaccompanied by a change in the stylar-determining area of the gene, would be indistinguishable by the tests from a loss of pollen activity. Because of the totally unexpected absence of mutants or recombinants, which results in a changed specificity of pollen and style, when the tests should have revealed them even in low frequency, it was necessary to discriminate between the two interpretations. The experiments designed for this purpose reported here were based upon the comparison of interactions of the mutant with the normal alleles in diploid pollen of artificially produced autotetraploids.

The normal S alleles when in pairs in diploid pollen grains of a tetraploid give a characteristic pattern of the three types of gene interaction—dominance, recessiveness and competition[3,4]. On the two-specificity interpretation of the mutants there are two possibilities: (1) The mutant alleles could have lost the pollen specificity-determining area, in which case there would be no interactions in diploid pollen. (2) The mutant had a changed specificity, in which case the pattern of interactions would be changed. On the one-specificity one-carrier interpretation in which we can postulate only a loss of activity in the pollen for the mutants, there are again two possibilities: (1) There could be a defect or block at a primary stage in gene activity, in which case the mutant allele will show no interactions. (2) The mutant allele might be active in one or more of the early stages of gene action but fails in the later stage to attain final phenotypic expression in the form of the characteristic antigen. If the experiments show that mutant S alleles do not interact in diploid pollen grains, then there is no discrimination between the two interpretations of the structure of the S gene, but on both interpretations this would mean an exclusion of the possibility that the mutations resulted in changed specificity. If, on the other hand, the tests show that the mutant alleles do interact with other alleles, then a discrimination can be made both on the structure of the genes and on the nature of the mutations.

The interactions found with the mutant alleles are compared with those of the original alleles in Table 1. The pattern of interactions is essentially unchanged, thus confirming the one-specificity one-carrier interpretation. But one new and highly significant interaction was found in the pollen grains with S_2 and S_4' alleles. The original allele S_4 is almost completely independent of S_2 in the diploid pollen grain. This was shown by the inhibition of $S_{2,4}$ pollen in styles with either S_2 or S_4 alone and by a stronger inhibition in an $S_{2,4}$ style. The $S_{2,4^1}$ pollen grains are inhibited in S_2 styles, little or not at all in S_4 styles, but the inhibition on $S_{2,4}$ styles is complete and fully as strong as the inhibition of an $S_{2,4}$ pollen grain. Thus the $S_4{}^1$ allele, inactive as it is in a haploid pollen grain, is restored to activity when accompanied by an S_2 allele. The S_2 restores the activity of $S_4{}^1$ not by imposing its own specificity but by allowing $S_4{}^1$ to produce its own original characteristic specificity.

Table 1

	S_2	S_3	S_4	S_6
S_6 (normal)	Strong Comp.	Strong Comp.	S_6 Dom.	-
$S_6{}^1$ (mutant)	Strong Comp.	Comp.	$S_6{}^1$ Dom.	—
S_4 (normal)	Slightly Rec. Indep.	Weak Comp.	--	S_4 Rec.
$S_4{}^1$ (mutant)	Restored to S_4	Weak Comp.	—	$S_4{}^1$ Rec.

Interaction of pairs of alleles in diploid pollen grains to show the comparison between normal and mutant alleles.

Comp., competition; Dom., dominance; Rec., recessiveness; Ind., independent.

This situation is most nearly paralleled by the restorer genes in *Neurospora* which restore the production of the active enzyme tryptophan desmolase in mutants which lack the enzyme. The enzyme appears to be absent in the mutants, but serological tests show that there is a protein present which is serologically identical with the active enzyme[5]. The complementary action of two different alleles to produce glutamic dehydrogenase in *Neurospora* heterocaryons is also similar[6]. The new situation in the S gene restoration is that the restorer is an allele of the restored, that both give products with different specificities and that the restored allele shows its original specificity and not that of the restorer. The origin of new specificities by mutation or recombination still remains a problem.

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Analogies between the Compensatory Responses of Fish and Crustacea to Horizontal Displacement of the Body

CERTAIN fish make compensatory swimming movements when they are stimulated by passive displacement of the body or by corresponding displacement of the environment. Experimental analysis shows that this response can be elicited by image displacement on the retina[1], by inertial stimuli[2], by tactile stimuli and by the passage of water over the surface of the fish[3].

In crabs and lobsters a similar set of mechanisms has been shown to exist. Buddenbrock and Friedrich[4], and later Dijkgraaf[5] showed that a rotational stimulus alone would produce compensatory eyestalk movements in crabs similar to those produced by a rotation of the visual field, while Dijkgraaf also showed compensatory responses to tactile stimulation of the legs and to water movement in *Palinurus vulgaris* Latreille[6]. Dijkgraaf proved that the statocyst in the crabs *Carcinus moenas* (L.) and *Maja verrucosa* Milne-Edwards was sensitive to angular displacement, and pointed out the similarity between resulting movements of the eyestalks of crabs and the eyes of vertebrates under similar experimental conditions[5]. However, blind *Palinurus*, though possessing a statocyst, failed to show any rotational sense[7]. On the other hand, Cohen found that when the statocyst of *Homarus americanus* Milne-Edwards was rotated, the discharge-frequency of its nerve underwent a change[8].

Similar experiments have recently been carried out on the behaviour of several species of prawns which confirm that there is a close parallel between mechanisms at work in prawns and crabs and those in fish. In both groups there are several mechanisms that detect displacement of the body; these are present in the same animal and are presumably used simultaneously. In *Palaemon serratus* (Pennant) and *Palaemon elegans* Rathke visual, inertial and tactile stimuli elicit compensatory movements of the eyestalks and to a varying extent of the organs responsible for controlling the direction of movement, that is, the antennæ, pleopods and telson. The statocyst has been shown to be essential to enable these animals to respond to rotation in the absence of visual and tactile stimuli. *Pandalus montagui* Leach, which has no statocyst and which does not respond to inertial stimulation, possesses an additional sense which enables it to respond to water movement when it is rotated; this sense normally augments the response to visual and tactile stimuli.

It is interesting to note that of the four possible mechanisms available to give information about the animal's displacement relative to its environment, no particular crustacean so far studied appears to use more than three to control its direction of movement. *Palinurus vulgaris*, although possessing statocysts, resembles *Pandalus montagui* in giving no response to inertial stimuli, but shows compensatory behaviour when stimulated by water currents, while the other prawns and brachyuran crabs[6] give compensatory eyestalk responses to visual, tactile and inertial stimuli but not to water movements.

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[1] Lyon, E. P., *Amer. J. Physiol.*, **12**, 149 (1905).
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The Teleostean Swim-bladder

The enigmatic secretion of gas into the teleostean swim-bladder has been attributed to the acidification of the blood bathing the gas gland epithelium[1]. The resultant local changes of pH, pCO$_2$ and pO$_2$ are thought to be sequestered from the rest of the circulation by counter-current exchange in the rete mirabile. This has been the only credible explanation; but its acceptance has rested upon its credibility. Even though the isolated gas gland epithelium actively converts glucose to lactic acid[2], there has been no evidence, either *in vivo* or *in vitro*, for an oriented hydrogen-ion extrusion into the solution bathing the serosal surface of the epithelium, the surface normally bathed by blood.

The following experiments indicate that the isolated surviving gas gland epithelium of the pollack (*Pollachius virens*, L.) selectively extrudes hydrogen ion into the solution bathing its serosal surface. The gas gland epithelium was dissected free of its serosal coat and exposed to oxygenated saline within 15 min. after removal of the fish from water. The epithelium was mounted as a flat 1-cm.^{2} membrane between simplified chambers[3] that permitted measurement of the trans-membrane potential and membrane conductance. The membrane separated two identical solutions having a volume of 5 ml. and the following composition: sodium chloride 200, potassium chloride 10, calcium chloride 5, magnesium chloride 2, glucose 25 and yohimbine 0·002 mM/l. The solutions were gassed with 100 per cent oxygen and experiments were conducted at an ambient temperature, 22° ± 1·6° C., which was probably supraoptimal. The bathing solutions were removed at 2-hr. intervals and the initial pH recorded after 15 min. of gassing with air passed through a soda-lime column. Using a glass and calomel electrode pair stable and linear within pH 0·05, the solutions were titrated to pH 7·0 with 12 mM sodium hydroxide.

The gas gland epithelia from five fish were observed for two successive 2-hr. periods. The rate of extrusion of hydrogen ions into the bathing solutions, mean and standard deviation of 10 observations, expressed as µequiv. cm.$^{-2}$ hr.$^{-1}$ was 0·53 ± 0·3 into the serosal and 0·08 ± 0·07 into the lumenal solution. The corresponding pH of these solutions was 4·8 ± 0·2 and 6·2 ± 0·8, respectively. The wet weight was 67 ± 37 mgm. Neither the amounts of hydrogen ion extruded nor the resultant hydrogen ion concentrations suggest that these observations were the result of a casual autolytic phenomenon. In my experience the rate of production of lactate by the frog gastric mucosa is 0·08 µequiv./105 mgm. wet weight/hr. It should be noted that the acidification of the solutions bathing the gas gland epithelium does not result from hydrogen ion transport from one solution to the other, as is the case for the gastric mucosa with an equivalent alkalinization of the serosal solution during acidification of the lumenal solution[4]. While no attempt was made to identify the metabolic acid generated by the gas gland epithelium, the titration curves suggest that extrusion of hydrogen ions was associated with a weak electrolyte the pK of which was considerably higher than that of lactic acid. In all experiments there was no significant trans-epithelial potential difference. It was less than 1 mV. The d.c. conductance was 7·2 mmhos. cm.$^{-2}$.

The rate of secretion of hydrogen ions by two gastric mucosae of the pollack was also determined for comparison. When the serosal surface of these mucosae was bathed by a somewhat different solution containing sodium bicarbonate 30, sodium hydrogen phosplate 1 and histamine 0·1 mM/l., and both solutions gassed by 95 per cent oxygen and 5 per cent carbon dioxide, the mean rate of hydrogen ion secretion was 1·5 µequiv. cm.$^{-2}$ hr.$^{-1}$, the pH of the lumenal solution 4·2, wet weight 155 mgm. and conductance 7·8 mmhos. cm.$^{-2}$. As expected, there was a significant gastric trans-mucosal potential of 10–20 mV.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, December 8

Royal Geographical Society (at 1 Kensington Gore, London, W.7), at 6 p.m.—"Journey Into Spring" and "Between the Tides" olour Films).

Tuesday, December 9

Physical Society, Low Temperature Group (at the Institute f Physics, 47 Belgrave Square, London, S.W.1), at 9.30 a.m.—iscussion Symposium on "Low Temperature Heat Exchangers".

Society of Chemical Industry, Agriculture Group (at 14 elgrave Square, London, S.W.1), at 10.30 a.m.—Forestry Meeting.

Institution of Mechanical Engineers, Automobile Division t 1 Birdcage Walk, Westminster, London, S.W.1), at 4 p.m.—Three apers on "The Dynamics of the Internal Combustion Engine".

Zoological Society of London (at the Zoological Gardens, egent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

Parliamentary and Scientific Committee, General Com-ttee (in Committee Room 12, House of Commons, London, S.W.1), 5.15 p.m.—Dr. E. E. Pochin and Prof. B. W. Windeyer: "The edical Problems of Living in the Nuclear Age".

Institution of the Rubber Industry, London Section (at the oyal Society of Tropical Medicine and Hygiene, Manson House, 6 Portland Place, London, W.1), at 5.30 p.m.—Mr. J. Ames: "Com-ounding and Vulcanisation of Silicone Rubber". 7 p.m.—Mr. C. G. ynch: "Practical Safety in the Rubber Industry".

University of London (at Imperial College of Science and Techno-gy, London, S.W.7), at 5.30 p.m.—Prof. D. B. Spalding: "Heat ransfer in Rocket Motors".

Iron and Steel Institute (in the Weir Lecture Hall of the Institu-ion of Naval Architects, 10 Upper Belgrave Street, London, S.W.1), t 6 p.m.—Dr. N. P. Allen, F.R.S.: "The Mechanical Properties of the errite Crystal" (Eleventh Hatfield Memorial Lecture).

Society of Chemical Industry, Chemical Engineering Group t 14 Belgrave Square, London, S.W.1), at 6 p.m.—Dr. R. Roberts: Some Aspects of Radiation Induced Chemical Processes".

Institution of Electrical Engineers, London Graduate and tudent Section (at Savoy Place, London, W.C.2), at 6.30 p.m.—r. H. E. Coles: "The Application of Electronics to Jet Engine ontrol".

Society for Analytical Chemistry, Biological Methods Group t "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m. —Fourteenth Annual General Meeting, followed by a Discussion eeting on "Methodological Reminiscences" opened by Dr. S. K. Kon.

Royal Aeronautical Society (in the Theatre, Park Lane House, 45 Park Lane, London, W.1), at 7 p.m.—Mr. S. S. Hall and Mr. A. homas: "Application of a Constant Frequency A.C. Electrical ystem to Aircraft and Missiles".

Royal Aeronautical Society, Graduates' and Students' ection (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Mr. E. C. owyer: "The Future of the British Aircraft Industry".

Wednesday, December 10

Iron and Steel Institute (at Caxton Hall, Caxton Street, London, .W.1), at 10 a.m.—Autumn General Meeting. Formal Business: lection of Members. Followed by technical sessions at Caxton Hall nd also at the Institution of Naval Architects, 10 Upper Belgrave treet, London, S.W.1.

Physical Society, Colour Group (in Room 102, Northampton ollege of Advanced Technology, St. John Street, London, E.C.1) t 3.30 p.m.—Mr. F. H. Ludlam, Mr. P. Saunders and Dr. J. Hallett: Some Colour Phenomena in Meteorology".

Geological Society of London (at Burlington House, Piccadilly, ondon, W.1), at 5 p.m.—Dr. C. B. Crampton: "Fabric Analysis f Moine and Cambrian Quartzites of the North-West Highlands of cotland" (paper communicated by Dr. F. Coles Phillips).

Eugenics Society (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. J. A. Fraser: "Human enetics at Two International Conferences".*

Society of Instrument Technology, Control Section (at anson House, Portland Place, London, W.1), at 6 p.m.—Mr. H. Gill: An Experimental Approach to some Control Problems of Multi-tand Rolling Mills".

Society for Analytical Chemistry, Microchemistry Group in the restaurant room of "The Feathers", Tudor Street, London, .C.4), at 6.30 p.m.—Discussion Meeting on "The Use of the Micro-cope in Analysis" opened by Mr. R. L. Causer.

Wednesday, December 10—Friday, December 12

European Association of Exploration Geophysicists (at the nstitution of Civil Engineers, Great George Street, London, S.W.1)—Vinter Meeting, opened by Sir Vivian Fuchs.

Thursday, December 11

Iron and Steel Institute, Iron and Steel Engineers Group at Caxton Hall, Caxton Street, London, S.W.1), at 10 a.m.—Meeting n "Vacuum Processes in the Iron and Steel Industry".

Sir Thomas Middleton Memorial Trust (in the Auditorium, The Wellcome Building, 183 Euston Road, London, N.W.1), at 5.30 p.m.—Dr. John R. Raeburn: "Economic Aspects of Uncertainties in British Agriculture" (Sixth Middleton Memorial Lecture).

Institution of Mechanical Engineers (joint meeting with the Institution of Electrical Engineers, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. C. M. Cock: "The 'Deltic' Locomotive".

Institution of Mechanical Engineers, Industrial Administration and Engineering Production Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Engineer in Production—His Training and Utilization".

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. G. Porter: "The Triplet State in Chemistry" (Tilden Lecture).

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Prof. P. C. C. Garnham and Dr. D. J. Lewis: "Parasites of British Honduras with special reference to Leishmaniasis".

Friday, December 12

Biochemical Society (in the Department of Biochemistry and Chemistry, The Medical College of St. Bartholomew's Hospital, Charterhouse Square, London, E.C.1), at 2 p.m.—378th Meeting.

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "The Teaching of Mathematics to Engineers" opened by Mr. M. Bridger.

Royal Institute of Chemistry, London Section (at Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 7 p.m.—Dr. J. K. Aiken: "The Application of Sequestering Agents".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. T. E. Allibone, F.R.S.: "The Fusion of Heavy Hydrogen".

Saturday, December 13

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. J. C. Jewell: "Exploration of the Andes".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Laboratory Technician (with either experience in laboratory, work, preferably in tissue culture, or the G.C.E. (Advanced) in two mathematical or scientific subjects) in the Tissue Culture Unit dealing with the production of kidney-cell cultures for growth of viruses—The Secretary, Research Institute (Animal Virus Diseases), Pirbright, Surrey (December 10).

Lecturer in Organic Chemistry at Birkenhead Technical College —The Director of Education, Birkenhead Education Committee, 63 Hamilton Square, Birkenhead (December 10).

Demonstrator or Tutorial Student in the Department of Chemistry—The Registrar, University College of North Staffordshire, Keele, Staffs (December 13).

Mathematicians (with a first- or second-class honours degree or equivalent in mathematics or physics) in the Health and Safety Branch of the Atomic Energy Authority, to join a section concerned with assessment of safety from criticality hazards in the handling and processing of fissile materials and theoretical research into the factors governing criticality and the effects of super-criticality—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancs, quoting Ref. 2768/T (December 15).

Experimental Psychologist to join the Behavioural Research Unit—The Registrar, The University, Sheffield (December 16).

Joseph Lucas Research Student (with a good honours degree in mechanical or electrical engineering or physics, and preferably some research experience), for research into the initiation of explosions in gases, vapours and powder clouds; and a Joseph Lucas Research Student (with a good honours degree in some branch of engineering, physics or chemistry), for research into the mixing of powdered materials—The Registrar, King's College (University of London), Strand, London, W.C.2 (December 17).

Usines Emile Henricot S.A. Research Student (with a good honours degree in some branch of engineering), for research into various aspects of the mechanical behaviour of ball mills—The Registrar, King's College (University of London), Strand, London, W.C.2 (December 17).

Assistant, Grade B (qualified to teach physics, and preferably the ability to teach applied physics), in the Science Department, Croydon Technical College, Fairfield, Croydon—The Chief Education Officer, County Borough of Croydon Education Committee, Education Office, Katharine Street, Croydon, Surrey (December 20).

Postdoctoral Fellow (with a Ph.D. or equivalent qualification) in the Department of Physical and Inorganic Chemistry, to carry out fundamental work on gas-phase chromatography—Prof. D. H. Everett, Department of Physical and Inorganic Chemistry, The University, Bristol 8 (December 20).

Demonstrator (Assistant Lecturer) in Physiology—The Registrar, The University, Leeds 2 (December 29).

Lecturer (with a knowledge of the meat industry or microbiological experience which can be applied to problems of food hygiene) in Applied Veterinary Pathology—The Registrar, The University, Liverpool (December 30).

Assistant Lecturer (medically qualified) in Physiology—The Registrar, The University, Sheffield (December 31).

Senior Demonstrator in Inorganic and Physical Chemistry; and a Research Fellow in Chemistry—The Registrar, The University of Melbourne, Carlton, N.3, Victoria, Australia (December 31).

Chair of Nuclear Engineering—The Registrar, The University, Manchester (January 1).

Senior Lecturer in either Inorganic and Physical Chemistry or in Theoretical Chemistry—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (January 1).

Scientific Officer or Senior Scientific Officer (with a Ph.D. in astronomy or allied subject; or appropriate science degree (first- or second-class honours) with at least three years relevant (for example, postgraduate) experience, and preferably a knowledge of celestial mechanics) at the Royal Observatory, Cape Town—The Civil Service Commission, 30 Old Burlington Street, London, W.1, quoting Ref. S.4910/59 (January 8).

Lecturer (Grade II) in Inorganic Chemistry—The Registrar, The University, Bristol (January 10).

Chair of Psychology in the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 12).

Chair of Philosophy in the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 30).

Chair of Geography—The Registrar, The University, Sheffield (January 31).

Lecturer in Botany at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, January 31).

Experimental Officer (at least 26, with a general science degree with G.C.E. in mathematics at advanced level) in the Research Branch of Headquarters, Royal Air Force Bomber Command, for work in the computer section (mainly programming and operating electronic computers)—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. A.427/8A.

Laboratory Technician (male or female, experienced in biology and interested in animals)—The Secretary, Furzedown College, Welham Road, London, S.W.17.

Lecturer, Grade IIa (with a first- or second-class honours degree) in Physics—The Principal, Paisley Technical College, 28–40 George Street, Paisley.

Lecturer (with good academic qualifications and industrial experience, preferably in the food industry) in Applied Microbiology—The Secretary-Treasurer, Royal College of Science and Technology, Glasgow, C.1.

Physicist (with a first- or second-class honours degree in physics), to undertake original research in the field of mechanical properties of high polymers—The Secretary, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22, quoting Ref. P.5.

Professor of Communications Engineering at the Indian Institute of Technology, Kharagpur, India—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting A.12/IND/244/TCS.

Senior Physicist (with first-class professional qualifications, substantial experience of work with radioisotopes or ionizing radiations and the organizational ability to manage a department) at the Radiochemical Centre, Amersham, to take charge of the Physics Department—The Group Recruitment Officer (1267/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Senior Research Officer or Research Officer (mathematical statistician with a good academic record), to undertake research, to lecture and to teach statistics at undergraduate and postgraduate levels—The Secretary, Institute of Statistics, The University, St. Cross Road, Oxford.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Home Defence and the Farmer. Pp. 32. (London: H.M. Stationery Office, 1958.) 1*s*. net. [710

Department of Scientific and Industrial Research. Problems of Progress in Industry No. 3: Management and Technology. By Joan Woodward. Pp. 40. (London: H.M. Stationery Office, 1958.) 2*s*. 6*d*. [710

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British Museum (Natural History). Economic Series No. 3A: Fleas: Their Medical and Veterinary Importance. Pp. 20. 2*s*. Bulletin of the British Museum (Natural History). Entomology. Vol. 6, No. 11: A Study of the Chironomidae (Diptera) of Africa South of the Sahara, Part 4. By Paul Freeman. Pp. 261–363+ plates. 30*s*. Vol. 6, No. 12: New Species of Indo-Australian Geo metridae. By L. B. Prout. Pp. 365–463. 28*s*. Vol. 7, No. 2: Th African Species of *Stivalius*, a Genus of Siphonaptera. By F. G. A. M Smit. Pp. 39–76. 10*s*. Vol. 7, No. 3: The Pseudococcidae (Hom. Coccoidea) Described by C. K. Brain from South Africa. By G. d Lotto. Pp. 77–120. 12*s*. 6*d*. Vol. 7, No. 4: Revisions of Mallophag Genera *Degeeriella* from the Falconiformes. By Theresa Clay. Pp 121–207+9 plates. 30*s*. Geology. Vol. 3, No. 8: An Early Pleistocene Mammalian Fauna from Bethlehem. By D. A. Hooijer. Pp 265–292+plates 32–35. 10*s*. Vol. 3, No. 9: The Upper Permia Flora of England. By H. M. M. Stoneley. Pp. 293–337+plates 36–40 17*s*. 6*d*. Zoology. Vol. 5, No. 5: A Revision of the Genera *Nidali* and *Bellonella*, with an Emendation of Nomenclature and Taxonomi Definitions for the Family Nidaliidae (Octocorallia, Alcyonacea). B Dr. Huzio Utinomi. Pp. 99–121. 7*s*. (London: British Museu (Natural History), 1958.) [71

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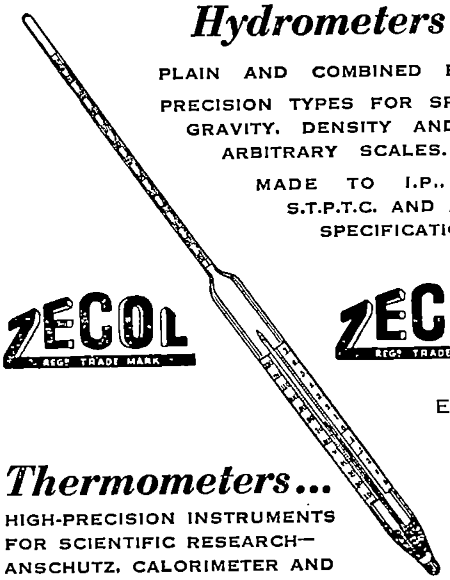

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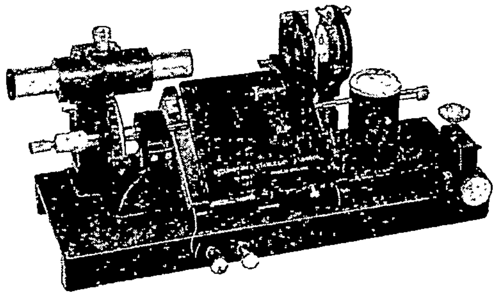

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THE FUNCTION OF UNIVERSITIES

IN an article on "Science and the Nation" in the October issue of *Foreign Affairs*, which reflects something of the outlook of his recent presidential report to the Carnegie Institution of Washington, Dr. Caryl Haskins points out that science is now an important element in general culture. Those training professionally for science and technology must accordingly become familiar with the context of the political world if they are to be capable of meeting the responsibilities that are likely to fall upon them. The rate and success of technical progress, Dr. Haskins emphasizes, is a function of a country's organizing capacity and application, and of the suitability of the chosen modes for development and of its tradition ; but it is also a function of the common heritage of the whole body of learning.

Dr. Haskins was addressing an American public, with the situation and needs of the United States primarily in his mind ; but much that he said is just as applicable to Great Britain. It is, for example, no less true in Great Britain than in the United States that the modes by which knowledge and insights of the natural world are obtained and most effectively assimilated, and especially the creation of new knowledge, are highly human factors, conditioned by the basic assumptions of each society ; and in both countries it is necessary to be on guard against blindly seeking to adopt modes which succeed elsewhere without forethought or regard to those conditions and assumptions. To-day none of the larger problems will be amenable to clear and final solutions. Rather, they will present prolonged tests of persistent and concentrated purpose. Except in war, processes of social change and growth in dynamic systems are continuous and involve every part and aspect of the whole of society.

Like many others, Dr. Haskins points to the necessary condition for creativeness in a free society, namely, wide and unimpeded horizons and the total freedom of the individual ; but he goes on to bring out the corollary, in such a society as he is depicting, of the increased social importance of intellectual attainment and of the urgent need to foster and expand the means to seek and cultivate intellectual powers. That is indeed the key-note of his article. What he writes further about the dual nature of science itself and the significance of the effective partnership of profound philosophy and practical experiment represented by modern science, on the proper use and cultivation of scientific man-power, and on the need for deeper study of the problems of management and communication, is both sound and important but really secondary to the main theme.

It is against this background that the pregnant chapter on educational problems in the recent report entitled "University Development"* from the University Grants Committee is most appropriately considered. "In our view," writes the University Grants Committee, "the first duty of the university to the student is to teach him how to think." The note is in harmony with that struck by Dr. Haskins, and both are sounded in a world where, despite its growing dependence on intellectual effort, there appears to be both a disturbing amount of illiteracy and a growing distrust of, or even opposition to, the intellectual.

That context gives an urgency to the whole problem which sharpens the wise words of the University Grants Committee. We in Britain have neither time nor man-power to spare, and we must do the best we can for the great bulk of our students within the limits of the three-year undergraduate course. Moreover, as the Committee points out trenchantly, if the university fails to teach the student to think, he is not very likely to learn to do so afterwards, and his capacity for development will be limited.

The great value of this chapter is that, as is done in so many earlier reports from the University Grants Committee, the problem is set in its true perspective, and the relative importance of the various factors appears. We see why the student needs not only competence in one field of knowledge but also access to related fields and a general appreciation of the art of learning. The contribution which different sources can make appears, as does the significance of the change in the social and economic background of students. Moreover, in a passage closely parallel with what Dr. Haskins has written, the Committee analyses the qualities of mind which distinguish a person of education and indicates precisely why a student needs to be shown that intellectual pursuits are enjoyable for their own sake, and to be given the sense of being in touch with creative work in which, if he does well, he may later be privileged to participate. Nor are we allowed to overlook the way in which the teacher can do this.

Here we are carried back to a preceding chapter of the report, for if the vital part is that played by the teacher, it is essential to attract teachers of the highest quality. Not only, however, are university lecturers rarely trained teachers ; what is more serious is that teaching is frequently regarded as an irritating interruption of the research which they consider to be their primary function, though it must be remembered that there are still those, like Dr. A. L. Goodhart in his Haldane Memorial Lecture of 1952, who maintain strenuously that a university is primarily a teaching institution. The University Grants Committee reiterates its conviction that the two functions of research and teaching are too intermingled for discussion of their relative importance to be fruitful ; nevertheless, teaching is unlikely to acquire the prestige and status the Committee regards as proper until universities cease to appoint, and promote, almost exclusively upon the evidence of papers published in the journals of learned societies.

More than this may well be required to make even university teaching attractive to as many of the ablest minds of each succession of graduates, but this is an essential condition of solving one limited aspect of the major problem of communication. A keener interest in teaching itself, however, is likewise a prerequisite of the concerted action on the part of schools, colleges and universities which the University Grants Committee urges in order to overcome the difficult problems of entrance requirements where they impinge on the question of general education. Moreover, if the amount of information which the student is required to absorb during his first-year course is to be reduced and the time saved used in preparing him for life in more important ways, teachers, rather than administrators, have a part to play, constructive and not merely negative. Merely from this point of view, the proposal under discussion at Cambridge for teaching the principles of science to men coming mostly from the humanities is welcome evidence of the stirring of minds among university teachers. Success will depend on vision as well as on constructive thought, and on the cumulative effect of a number of comparatively small changes, all inspired by a definite purpose and by a clear conception of what the university should try to do with the students entrusted to its care.

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* University Grants Committee. University Development 1952–1957. Pp. 92+8 plates. (Cmnd. 534.) (London: H.M. Stationery Office, 1958.) 5*s*. 6*d*. net. See also *Nature*, November 1, p. 1199.

Some, but by no means all, of these opportunities are noted by the University Grants Committee. There is the matter of technicians and of other assistants, the scarcity of whom is responsible for much waste of highly trained scientific man-power in academic research. Some improvement in this respect could have other advantages as well as the reduction of this kind of waste: it might well make teaching duties less repugnant to the younger staff in particular, because they would be able to make more effective use of the time at their disposal for research, and teaching would not be regarded as so serious a distraction from original work. Moreover, administrative duties could sometimes be considerably reduced by a reasonable provision of typing facilities. Indeed, the more evident it becomes that, whether we regard the university from the point of view of staff or student, we are dealing with a strictly limited national resource which is both indispensable and irreplaceable, the greater the care that should be taken to see that highly trained man-power is not wasted on duties that do not require its exercise, and that university places and privileges are not offered to those unlikely to benefit by them.

More positively, however, if teaching is to regain the prestige it enjoyed when Jowett's view was fashionable—that education is the first and final function of a tutor and that the pupil and not research must come first—something more than negatives is required. Fortunately, the very field of communication itself is opening up new possibilities, and while we are required to think out anew the content of many courses in the light of the immense expansion of knowledge and the contracting amount of time available, new techniques are available to assist in resolving some of our problems. The task of communication, even of inter-communication, has its own attractions, and in solving some of its complex problems, we may well find help in solving the parallel problem of general education.

One of the auxiliary factors to which the University Grants Committee gives more than a passing glance is the university library; and here it may be said that this factor is as essential in science and technology as in the humanities or the social sciences. The standard of library provision profoundly affects the effectiveness of teaching generally, and although it does determine the practicability of research in science, as it may well do in the humanities or in the social sciences, it may have repercussions on the extent of scientific research. Inadequate provision of scientific periodicals or major and highly expensive reference books can cause serious delay, and may even lead to waste or duplication of effort.

Apart, however, from its bearing on the waste of skilled man-power and on the attractiveness and efficiency of teaching in some fields, the quality of library provision can bear on yet another factor. Ten years ago, urging the need for more thinking about the importance of existing knowledge, Sir Walter Moberly suggested that we need more books which throw new light on the significance and interrelations of old facts, and that the universities should encourage and honour not only discoverers of facts hitherto unknown but also explorers of ideas and re-thinkers of values. An adequate library is an essential adjunct in the kind of creative thought and writing which Sir Walter had in mind, and this is not the least important of the reasons why library expansion needs to proceed *pari passu* with university expansion, and probably rather faster than it has been doing generally over the past decade. It is also an added reason for welcoming the study of function and design in this field which the Nuffield Foundation is fostering.

Nor is this unrelated to the prime purpose of a university and to the establishment of teaching in its proper status in both external and internal regard. When the universities are recognized as effectively fulfilling this function of supplying the large numbers of well-educated men and women needed, whatever their special field of work, the university teacher would be assured of a position in the public esteem which will attract to that calling a sufficient supply of our ablest young men and women. Public opinion alone can dispose of any tendency to discredit the occupation of university teacher, but the university teacher himself can do something to encourage public understanding.

It may be given to only a few to produce books of the calibre suggested by Sir Walter Moberly; but the contribution of such books to public understanding of the work of the universities is not negligible. Many more, however, may find an opportunity of participating in the regional work of the university and in adult education, and through both of these a direct impact is made on the public. In this way a decisive contribution could well be made to the formation of a better-educated community, on the very existence of which the free world to-day depends. There are, of course, strict limits to what is possible in such fields. First things must come first, and neither the university nor the individual teacher should be deflected from work of university standard. It is only with a very clear idea of what is the place of the university in the modern world, and what it should seek to bring to its students, that either the university as an organized body or the individual teacher should accept extra-mural duties or responsibilities.

Nevertheless, without accepting some such duties or responsibilities and keeping them in balance with other and primary responsibilities, the universities can scarcely hope to fulfil their function in the world to-day. They need such external co-operation in shaping their own methods to the needs of to-day. Increasingly they depend on public understanding for the financial support required to make their teaching adequate and their research effective. As was resolved at the regional European seminar on the "Universities and Adult Education" at Bangor in September 1956*, arranged by the United Kingdom National Commission for the United Nations Educational, Scientific and Cultural Organization, in the rapidly changing world of to-day adult education in all its many forms is more than ever necessary to help men and women in making the many adjustments which rapid change requires ; it is essential to the development of their individual powers of understanding, judgment and enjoyment, and for providing society with well-informed and thoughtful leaders for all sectors of industrial, social and civic organization.

The universities in Great Britain, or in any other country, cannot be indifferent to enterprises of such profound social importance. How that assistance is best given will vary widely from country to country, even from university to university, and its extent can only be decided in relation to a university's resources and other responsibilities. That urgent and intensive thought should be given to the nature, the magnitude and the technique of the universities' contribution in this field even in this time of expansion and stress is undeniable ; nor should it be forgotten that the response of the universities to this call may not only have valuable effects in promoting public understanding and support of their primary work but also may in turn lead to fresh light being thrown on some of their own difficult problems in general education and courses and the like. Education must be regarded as a whole. However admirably the universities may fulfil their function of providing society with trained, informed and inquiring minds, capable of clear thinking and balanced judgment, those minds will only be able to work effectively in the framework of a society that has some understanding and appreciation of the nature of their capabilities, and is prepared to allocate the resources essential for the universities to continue their work. Adult education and regional work from one point of view are part of the work of promoting effective public relations, which the growing dependence of the universities on public support makes more and more necessary.

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* Ministry of Education. Report on the Regional European Seminar on the Universities and Adult Education, Bangor, North Wales, September 1st–14th, 1956. (Arranged by the United Kingdom National Commission for UNESCO.) Pp. xii+155. (London: H.M. Stationery Office, 1957.) 5*s*. net.

THE HISTORY OF A DECIPHERMENT

The Decipherment of Linear B

By John Chadwick. Pp. xii+147+2 plates. (Cambridge: At the University Press, 1958.) 18*s*. 6*d*. net.

NOT the least interesting side of Michael Ventris's genius was his willingness to think aloud, and to make mistakes in public. In the two years of intensive work which ended in June 1952 with the decipherment of the so-called Linear B tablets, he prepared and circulated twenty 'work notes', totalling 176 foolscap pages. "All the rough working," Chadwick points out, "all the mistakes are exposed to view." In 1940, Ventris, then eighteen years old, had published an article suggesting that Etruscan was the language most likely to provide the clues to the decipherment of Linear B ; and this idea held him in thrall until the last moment, when, almost against his will, the work itself drove him to the correct, and decisive, conclusion that the language of the tablets was Greek.

We thus have an interesting case study in the triumph of sound method over prejudice and presuppositions. For a generation or more attempts to decipher Linear B had made no progress whatsoever simply because no one thought to apply the well-established principles of cryptography. Instead, reputable scholars and cranks alike did nothing more sensible than make guesses, a number of which were published, even by the most eminent of university presses, despite the fact that any intelligent reader could have exposed the 'results' with ease. Why this situation should have prevailed so long and without significant exceptions, until two Americans, Alice Kober and E. L. Bennett, finally began the obvious work of cryptographic analysis, is a mystery, though perhaps no more so than many similar blind spots in the history of science. Ventris built on their work and brought it to a rapid and successful conclusion. Because he clung for so long to his Etruscan theory, and because he did his thinking out loud, the work notes and related documents provide the raw material for a valuable contribution to the history of scientific discovery ; to its psychology, I might say. It is not often that not merely the operations but also the day-to-day thinking behind them, behind the false starts and mis-steps as well as the successes, are recorded so freely.

In a way, therefore, it is a pity that Chadwick, who was Ventris's close collaborator from June 1952, chose to write another kind of book. This little work is a reliable popular presentation of the Mycenæan tablets, their discovery, decipherment, and contents. (Readers of *Nature* will find an admirable summary by R. M. Cook in a review of another work on pp. 152–53 of the issue of July 19, 1958.) Only Chapter 4 offers a little of the material from the work notes and voluminous correspondence, enough to correct some of the misapprehensions about Ventris's methods current even in some professional circles (specifically among the few scholars who still refuse to accept the validity of the decipherment), probably enough to satisfy most lay readers, but far from enough for the permanent record which ought to be made. It can be argued that the disproportionately long chapter entitled "The Decipherment and its Critics" is unnecessary. Neither Beattie in Edinburgh nor

Grumach in Berlin will be convinced by these twenty pages, and for the rest of us the test of the decipherment is in the further work based upon it, not in the endless repetition of the sterile quarrel which has been carried on for nearly five years in both learned journals and the Sunday newspapers. Much more would have been gained by devoting these twenty pages to further exploration of the actual work of decipherment.

The final chapter, "Life in Mycenæan Society", though it has little of the air of polemic about it, is a deceptively valuable contribution to a still vigorous debate. Indiscipline and romantic guesswork did not come to a sudden end with Ventris's decipherment: they merely moved from decipherment to interpretation. Enthusiasm far outran the evidence, which is severely limited by both the incompleteness of the decipherment (only six years old, after all) and the very restricted contents of the tablets. Inevitably, the layman's knowledge comes from the popular presentations, and they have tended to exaggerate what we know, sometimes quite wildly. It is therefore useful to have the weight of Chadwick's authority, in a popular work, placed in the scales on the side of caution and of frank recognition of how little we still know about Mycenæan society.

M. I. FINLEY

WESSEX LONG AGO

Wessex Before the Celts

By Dr. J. F. S. Stone. (Ancient Peoples and Places, Vol. 9.) Pp. 207 (72 plates). (London: Thames and Hudson, Ltd., 1958.) 25*s*. net.

NOBODY who knew the late Dr. J. F. S. Stone can read this book, "Wessex", without much sorrow at his sudden and untimely death. Indeed, the work has only been finally completed and passed for press thanks to the kindness of Prof. Stuart Piggott.

The book covers a considerable area of ground and deals with a long period of time—the Mesolithic epoch until the arrival of the Celtic folk. There are 148 pages of text, a reasonable bibliography and 38 pages of illustrations. Nowadays in Great Britain there are a large number of amateurs interested in archaeology, and this book, like the others in the series, is designed for them. The space available is barely sufficient to give a general picture of the Wessex scene during the various periods and specialists must not expect any detailed accounts. The Palæolithic period is omitted, and the work starts with a few words on the Mesolithic (forest) cultures as a background to a rather fuller account of the first Neolithic inhabitants. There follow a few pages devoted to the various barrows of these times, and the flint mines whence came the raw material for tool making. The later Neolithic invasions and the coming of the Beaker folk are next considered in greater detail, and these lead on naturally to an excellent account of Stonehenge, Avebury, etc. A couple of chapters on Bronze Age times carry the story on to the epilogue, "Celtic Wessex". The book as a whole is a good example of its kind and can be recommended without reserve for those readers, non-specialist but interested generally in the past, for whom it was composed.

M. C. BURKITT

THE INDIAN AGRICULTURAL SERVICE

Agricultural Research in India

Institutes and Organisations. By Dr. M. S. Ranc
hawa. Pp. v+448+79 plates. (New Delhi: India
Council of Agricultural Research, 1958.) Rs. 20
40*s*.; 6 dollars.

THREE facts will suffice to make the importanc
of agricultural research to India abundantl
clear: (1) that three-quarters of the populatio
depend directly on agriculture for a living; (2) tha
the need for national action to improve agricultu
was first officially stated by committees set up i
1880, 1888 and 1901 with the ominous name (
Famine Commissions; and (3) that each year no
food has to be grown for 5,000,000 additional peopl
so that only to maintain present standards of nutritic
demands a steady and continuous rise in productio

This handsome volume, prepared by the Vic
President of the Indian Council of Agricultur
Research, shows how much the Indian Governmen
is spending and how it organizes research in i
attempts to get the knowledge that will be neede
before the fear of famine can be banished and tl
living standards of the bulk of the population i
creased. The book is less one for reading than f
reference, with its main value to find out whe
different crops and problems are being studied, wh
is working on them, and what body is responsible f
finance, administration and for co-ordinating wo
done in the different States. Nevertheless, tl
descriptions of the work at the various institutes a
detailed enough to show that, despite the very man
problems still waiting a solution, much has bee
found out that could improve yields by the bett
feeding of crops and livestock, by the control of pes
and diseases, by irrigation and by the growing (
higher-yielding varieties. The book deals only wit
research, and some information about the importa
and difficult problem of getting discoveries applie
would have added to its value.

It is necessary only to turn the pages to be ir
pressed by the growth in agricultural research, fro
its beginnings in 1905 at the Imperial Agricultur
Research Institute, Pusa, Bihar, which was destroy
by the earthquake of 1935, to the present nine centr
research institutes, several commodity research i
stitutes and the more than thirty research statio
and farms in the different States. The photograp
leave no doubt that many large and magnifice
laboratories have been built, but provide litt
evidence on the standard of the physical equipmen
However, staff is the most important equipment (
any research establishment, and here also the numbe
are impressive, at least at first sight. The India
Agricultural Research Institute, the new Pusa base
on Delhi, with about 350 graduates, is probab
much the largest in the whole Commonwealth, ar
some of the others are also of considerable size. Eve
so, India is so vast and conditions so varied tha
many more could undoubtedly be justified, for as
proportion of the population engaged in agricultu
the number is much below that in many oth
countries. But quantity of staff is less importa
than quality; although government may provi
new buildings, physical equipment, organizing cor
mittees and lakhs of rupees for salaries, only tl
research workers can produce results. It is r
exaggeration to say that the prosperity of Ind

may depend on the outcome of the efforts of those whose names are listed at the end of this book, and all will surely join in wishing them every success in their vitally important work. F. C. Bawden

AERONOMY

The Upper Atmosphere

By Prof. H. S. W. Massey and Dr. R. L. F. Boyd. Pp. xii+333+28 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 63*s*. net.

THE science of the upper region of the terrestrial atmosphere, where dissociation and ionization are important, has many facets. Because of the various interrelations that exist, none of these can be treated properly in isolation. Yet few people have the time and ability to become experts in the whole of this rapidly expanding science (which has been given the name 'aeronomy', following a suggestion by Prof. Sydney Chapman). For some years past there has been a need for an up-to-date book giving a survey of the entire field in simple terms so that a specialist in any one branch can readily obtain at least a general understanding of the work being done in other branches; for example, so that a radio man may learn something of the nightglow without bothering himself with the notation of molecular spectra, and so that a photochemist may learn something of the theory of the diurnal variations in the geomagnetic field without mastering the mathematics involved. There has also been a need for an elementary text which can be recommended to post-graduate students. Prof. Massey and Dr. Boyd do much to meet these needs by their admirable new book, "The Upper Atmosphere", though, regrettably, they do not include any references to the original literature.

The first two chapters are introductory in character. One of them recalls the basic principles of the relevant physics in elementary sections on electricity and magnetism, on wave motion of various types and on atoms and molecules; the other gives a short review of the main properties and phenomena of the upper atmosphere, anticipating the later, more detailed accounts.

These are followed by three chapters on the principal types of probe used—sound, radio and material. The chapter on material probes is particularly valuable in that it contains much information on balloons and rockets which has never been collected together before. Towards the end of the book there is a related chapter on artificial satellites, giving an interesting discussion of some of the important investigations which may be carried out with their aid.

The remaining chapters cover the following: the chemisphere and the ionosphere; the night-glow and the aurora; aerial tides and magnetic effects; solar, magnetic and ionospheric disturbances; meteors; cosmic rays. As would be expected, the exposition is lucid.

In addition to the six plates in colour and the twenty-two plates in black and white, there are a large number of instructive line drawings, many of them specially prepared. An excellent index adds considerably to the usefulness of the book, which should be in the library of every serious research worker in any branch of aeronomy.

D. R. Bates

DIOPHANTINE ANALYSIS

An Introduction to Diophantine Approximation

By Dr. J. W. S. Cassels. (Cambridge Tracts in Mathematics and Mathematical Physics.) Pp. x+166. (Cambridge: At the University Press, 1957.) 22*s*. 6*d*. net.

THE approximation to an irrational θ by rationals p/q depends on the distance between $q\theta$ and the nearest integer, a distance which Dr. J. W. S. Cassels writes as $\|q\theta\|$. This specifies the homogeneous problem; the inhomogeneous problem concerns $\|q\theta - \alpha\|$, and each problem can be generalized to that of simultaneous approximation to a finite number of θ's. In Chapters 1 and 3 of this Cambridge Tract, the classical material is neatly and efficiently displayed. Chapter 2, a little more difficult, deals with the curious Markoff 'chain', which disposes of one exceptional θ after another, and the related results about quadratic forms; this includes a new and hitherto unpublished 'isolation' theorem due to C. A. Rogers. In Chapter 4 on the distribution of the fractional part of $q\theta$ in the interval (0,1) or of the simultaneous fractional parts for a finite number of θ's, the method of trigonometrical sums, due to Weyl and developed by Vinogradoff, is employed. The next chapter discusses a type of duality between problems concerning related (transposed) sets of linear forms, first examined by Mahler. Chapter 6 is particularly interesting, since it deals with Roth's theorem, that if ξ is any algebraic number, that is, a root of an equation:

$$a_0u^n + a_1u^{n-1} + \ldots + a_n = 0$$

where the a's are integers, then there are only a finite number of pairs of integers p,q such that:

$$|\xi - p/q| < 1/q^k$$

if $k > 2$. Since there are infinitely many solutions if $k = 2$, Roth's result is an end to a story which began about fifty years ago with Thue's remarkable theorem, that the equation:

$$a_0x^n + a_1x^{n-1}y + \ldots + a_ny^n = c \quad (n \geqslant 3;\ c \text{ integral})$$

(where the form on the left is irreducible) cannot have an infinite number of integer solutions x,y. To obtain this, Thue used a weaker form of Roth's theorem, with $k = \frac{1}{2}n + 1$, a value improved by Siegel (1921) and Dyson (1947), until in 1955 Roth closed the gap completely with the best possible value of k; notably it is independent of n. The International Congress of Mathematicians, meeting at Edinburgh in August this year, recognized the brilliance of Roth's work by awarding him one of its two Fields Medals.

If $C > 0$, the inequality $\|q\theta\| < C/q$ has infinitely many solutions for almost all θ, that is, save for θ's forming a set of zero Lebesgue measure. This is the basis of Chapter 7, on metrical theory, developed in a series of papers by Dr. Cassels during 1950–51. The final, rather highly technical, chapter discusses the Pisot–Vijiyaraghavan numbers.

Dr. Cassels has selected his material carefully and expounds it with crisp clarity. The volume is a genuine introduction, for the reader requires no special knowledge of number theory; even in the final two chapters, only a very rudimentary acquaintance with Lebesgue measure and with algebraic numbers is supposed. Yet the author manages to bring us into effective contact with several important lines of present-day research, and his book must rank high among the famous Cambridge Tracts. T. A. A. Broadbent

Conformal Transformations in Electrical Engineering

By Dr. W. J. Gibbs. Pp. viii+219. (London: Chapman and Hall, Ltd., 1958.) 45*s*. net.

THIS book is one of the series of advanced engineering text-books written by members of the technical staff of the British Thomson-Houston Company. It develops the mathematics of the electromagnetic field, the theory of complex numbers, conjugate functions and conformal transformations. Numerous practical examples are worked out in numerical detail, including configurations with n right angles where $n = 0,1,2, \ldots$, and a chapter is devoted to each of the first three values of n. The theory of elliptic functions and integrals is presented in several chapters, and in the last chapter examples of problems needing this theory are worked out. One of these is that of a succession of equal slot openings opposite a solid face (the theory here uses an elliptic integral of the third kind). Clarity abounds in this book. The printing is clear, the numerous diagrams are easy to understand and the exposition is not too concentrated nor diffuse. In fact, the classical subject-matter is treated in classical style. This even extends, unfortunately, to the references. Very few engineers will bother to consult the original papers (1867 and 1869) of Schwartz and of Christoffel, let alone read the German text. There is not a single reference to a paper after 1928, and the reader who wants access to more recent work will have to spend quite a time wading through the volumes of *Electrical Engineering Abstracts*.

Electrical engineers, especially those concerned with design, will be aware of the present-day tendency to the automatic use of an electronic computer for design, even in cases where a mathematical solution is possible. The superiority of the latter, especially for studies relating to the effect of parameter variation, is undisputed. Thus there is a real need to make available, in easily accessible form, a statement of how far one can expect to go in providing a mathematical rather than a purely numerical solution. The present book does this admirably so far as conformal transformations are concerned.

L. S. GODDARD

The Interference Microscope in Biological Research

By Dr. Arthur J. Hale. Pp. xi+114. (Edinburgh and London: E. and S. Livingstone, Ltd., 1958.) 20*s*. net.

THE interference microscope was developed to overcome certain deficiencies in the phase-contrast microscope. In my opinion it will never replace the latter for routine observational work, but its great advantage is that it can be used for measuring optical-path differences. From the biological point of view the fact that the optical-path difference is proportional to the dry mass per unit area of tissue opens up new fields of research concerned with 'weighing' living cells and tissue sections. Dr. Hale gives a very useful general account of the theory and practice of interference microscopy for the non-specialist reader. He begins with an account of light waves and their interference and ends with an appendix on wave-motion and polarization of light. The rest of the book deals with the various types of interference microscope, interpretation of images, measurement of optical-path differences, cytochemical calculations and sources of error. A possible criticism is that too much space is devoted to systems of only theoretical interest. Multiple-beam methods, for example, as Tolansky has stressed, are of very limited value in biology. The description of the Smith-Baker microscope, on the other hand, is rather incomplete, and the diagrams do not refer to the commercial instrument. No mention is made of the need to use a half-wave plate to interchange the ordinary and extraordinary rays and the explanation of the action of the Sénarmont compensator may puzzle some biologists. There is a useful summary of methods for deriving various cytochemical quantities; but no detailed examples of biological applications are given. Possibly more stress could have been placed upon the fact that most measurements with the interference microscope only provide the dry mass per unit area and not the total dry mass of a heterogeneous cell. The measurement of the latter quantity may require elaborate apparatus and may be extremely tedious. Until this limitation is overcome, the full potentialities of interference microscopy will not be realized.

R. BARER

Gas Chromatography

A Symposium held under the auspices of the Analysis Instrumentation Division of the Instrument Society of America, August, 1957. Edited by Vincent J. Coates, Henry J. Noebels, and Irving S. Fagerson. Pp. xii+323. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 10 dollars.

HERE are collected together twenty-seven papers on various aspects of gas chromatography which were presented at the symposium held by the Instrument Society of America in 1957, together with reports of the discussion which followed each paper.

The different topics covered include theoretical studies of gas chromatography, new experimental techniques, a variety of analytical applications, and the design and development of automatic process analysers. Some of the contributions are of outstanding importance in their field, and stimulated spirited discussion outside the formal sessions of the symposium; among these are the paper by M. J. E. Golay on the theory and practice of gas-liquid partition chromatography with coated capillaries; a paper by C. Phillips which describes the use of metal salts as stationary phases to obtain greatly enhanced separation of substances capable of forming complexes with those metals; and papers by B. O. Ayers, and by C. C. Helms and H. N. Claudy, outlining some of the problems encountered in the design and operation of automatic continuous process analysers. The construction of a laboratory gas chromatography unit capable of operation at 500° C. and above is described by H. R. Felton; this is noteworthy for its simplicity and extremely low cost in comparison with the majority of commercial instruments. The factors affecting the design and operation of thermistor-type katharometers are discussed in considerable detail by C. B. Cowan and P. H. Stirling, and a critical study of the copper-oxide combustion method of detection is contributed by S. D. Norem. This book is similar in general outline to the volume edited by D. H. Desty and C. L. A. Harbourn containing the proceedings of the Institute of Petroleum 1956 symposium, but its value is enhanced considerably by the inclusion of an excellent bibliography in addition to subject and author indexes; it can be recommended as a worthy addition to the literature on this subject.

N. H. RAY

THE ROYAL SOCIETY

ANNIVERSARY ADDRESS*

By Sir CYRIL HINSHELWOOD, P.R.S.

AWARD OF MEDALS, 1958

Copley Medal : Prof. J. E. Littlewood, F.R.S.

At the present time J. E. Littlewood is, by general agreement among mathematicians, by far the most eminent pure mathematician in Britain. His papers contain deep and difficult solutions of important problems, and have opened new fields for investigation. The papers on the minimum modulus of integral functions of finite order (1908) led the way to further developments, including a major problem only recently solved. The Tauberian theorem for power series (1915) was an important step forward from Tauber's original theorem and even from Hardy's Tauberian theorem for Cesàro summation, and might be regarded as the true beginning of what is now recognized as an independent subject—Tauberian theorems. Among Littlewood's results on the theory of functions he showed (1924) that the coefficients a_n of schlicht functions regular in the unit circle satisfy the inequality $| a_n | \leqslant en | a_1 |$ for all n; this constituted an important advance, and since then the problem of whether the constant e can be replaced by 1 has become one of the famous unsolved problems of pure mathematics. His proof (1914) that a long-standing conjecture about the number of primes less than a prescribed number is false is one of the surprises of modern mathematics, for the correctness of the conjecture is supported by all available empirical evidence, including numbers up to a thousand million. Mention must also be made of his extension of Fatou's theorem to subharmonic functions, and his excursion into the applied mathematics of anti-aircraft fire in the First World War.

Besides all this work which he did alone, Littlewood was an important member of the partnership so famous throughout the world that it has created a name, Hardy–Littlewood analysis, for a certain type of mathematics cutting across the natural boundaries of subjects just as its technique cut through difficulties. In the best kind of mathematical collaboration it is impossible for the authors to say to which of them any particular piece of work can be attributed, but Hardy's immense admiration for Littlewood, expressed in his "Apology" and verbally on many occasions, suggested that all the most difficult parts were done by Littlewood. Although Hardy was too modest, a certain kind of unexpectedness and difficulty is characteristic of much that Littlewood published independently.

He also collaborated with R. E. A. Paley in a very important series of papers on Fourier series, with A. C. Offord in a long paper (1948) on the distribution of zeros and α values of a random integral function, and with M. L. Cartwright on non-linear differential equations connected with radio. His work with Paley provided the starting-point for extensive investigations by others. His work on non-linear differential equations, begun in 1945, is still continuing and has covered a wide field, including some fixed-point theorems in plane topology suggested by the results on differential equations.

He has inspired many generations of pupils, and his lectures and book on the "Theory of Functions" have formed the starting-point for some of the most outstanding work by young English mathematicians.

Rumford Medal : Sir Thomas Merton, K.B.E., F.R.S.

Sir Thomas Merton has devoted himself to research in spectroscopy for close on fifty years. His early papers dealt with absorption spectra, but he soon turned to the emission spectra of gases and the causes of the variations in the spectra produced under different conditions. These were of particular interest in relation to the spectra of celestial bodies. In a paper in 1916 with the late J. W. Nicholson a most ingenious method of measuring the distribution of intensity in broadened spectrum lines revealed marked discontinuities in the intensity curves, pointing to the existence of several component lines. The application of the same method to the investigation of hydrogen and helium lines threw much fresh light on the transference of energy from one series to another under different conditions, and the distribution which is characteristic of some stellar radiators was reproduced in the laboratory for the first time.

Merton's Bakerian Lecture in 1922 on the spectrum of hydrogen cleared up a number of discrepancies in the secondary spectrum of hydrogen, which was shown to be due to the hydrogen molecule. It also emphasized the profound influence which traces of impurities can have on gas spectra. This was the subject of a number of subsequent papers dealing mainly with the influence of the rare gases on the spectra of other elements. All his work has been distinguished by the elegance and ingenuity of his experimental methods.

The rarity and expense of good diffraction gratings led Merton to devise in 1935 a method of copying them without loss of optical quality by applying a thin layer of a cellulose ester solution to an original plane grating. This pellicle he detached after evaporation of the solvent and applied its grooved surface to a moist gelatine film on a glass plate. After evaporation of the water the gelatine was found to bear a faithful record of the original rulings.

In 1948 Merton made an important basic advance in the science of ruling diffraction gratings. Since 1880 these had been ruled groove by groove by the method laid down by Rowlands. In place of this Merton ruled a very fine helix continuously on a steel cylinder which he then opened out upon a plane gelatine-coated surface by his copying method. No lathe could, however, rule a helix free from periodic errors of pitch, and these Merton eliminated by means of a very simple and ingenious device. It consisted of a 'chasing lathe' by which a secondary helix was cut on the same cylinder with a tool guided by a 'nut' lined with strips of cork pressed upon the primary lathe-cut helix. This device eliminated entirely the periodic errors, as they were averaged by the elasticity of the cork.

Merton then handed over these processes to the National Physical Laboratory for further development, and they have formed the basis of a considerable research programme. The 'blazed' gratings made by the Merton–N.P.L. method are already of great value in making available cheap infra-red spectrometers of high resolving power which are finding many applications in research and industry. The ruling of long gratings by this method has made possible their use as scales for engineering measurement and machine tool control.

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* Delivered at the Royal Society on December 1.

Royal Medal (*A*) : Prof. H. S. W. Massey, F.R.S.

Prof. H. S. W. Massey is distinguished alike in the fields of experimental and theoretical research. His early experimental work was concerned with elastic and inelastic collisions between electrons and atoms. In collaboration with Bullard he carried out a series of experiments in which diffraction effects were demonstrated and studied in detail. With Mohr, and others, he carried through a large number of detailed calculations, and in particular he exploited the variational method with great thoroughness. His review in "Reports of Progress in Physics" (1942) did much to give a pattern to the experimental results by emphasizing the significance of the near-adiabatic conditions.

During the same period he contributed to the early theoretical treatment of neutron interactions, and somewhat later was responsible for a large volume of work on the binding energies of the simplest nuclei.

Massey has paid particular attention to negative ions. His writings on this subject systematized our knowledge and stimulated much research. He discussed for the first time why only some atoms can accommodate additional electrons to form negative ions, listing the various mechanisms by which these ions may be formed and destroyed. With Mott he wrote "Theory of Atomic Collisions", and with Burhop "Electronic and Ionic Impact Phenomena". These have come to be accepted as the standard accounts of their respective subjects.

Massey was the first to apply the theories of electron attachment and recombination to problems of the ionosphere, and he led the way in reviewing the results of experiments in this field and in trying to explain them. The difficulties in the way of any entirely satisfactory explanation led him to investigate and discuss a wide range of atomic and molecular processes which might be operative in the upper atmosphere.

It is not surprising that with the advent of the rocket as a means of upper atmospheric exploration, Massey should have made himself the pioneer British worker in this new field. Besides developing equipment for this work, he is heavily engaged in assembling more powerful apparatus for the laboratory investigation of collision process. His personal contributions to our knowledge of ionospheric physics are already considerable : the preparatory work going forward in his department makes it more than likely that the future contributions of the research team which he directs will be of equal importance.

Royal Medal (*B*) : Prof. A. L. Hodgkin, F.R.S.

Prof. A. L. Hodgkin has taken a leading part in nearly all the important advances in our understanding of the excitable membranes of nerve and muscle in the past twenty years.

His first experiments clearly demonstrated that local electrical currents, set up in the cable-like structure of the nerve fibre by the approaching impulse, were the stimulus which excited the next section of nerve. Hodgkin's experiments provided the first experimental proof that the local currents were of sufficient magnitude. Further direct evidence for this mechanism was his demonstration that the conduction velocity of the nerve impulse could be reduced by increasing the electrical resistance, outside the nerve, through which the local currents flow.

Hodgkin was a pioneer in measuring the electrical constants of nerves by square-pulse analysis ; he and Cole measured the core and sheath resistances of the squid giant nerve fibre ; later, with Rushton, he extended the method to measure the capacitance of the nerve membrane.

He was the first to observe and record the 'sub-threshold' responses of nerves and muscles when stimulated with currents too weak to initiate a propagated impulse.

Hodgkin was among the first to record the electrical activity of nerve and muscle with electrodes *inside* the single cell, a powerful and, eventually, much-used technique. He and Huxley found by this means that the resting potential across the membrane was reversed during the nerve impulse. Hodgkin and Katz then demonstrated that the reversal of potential varied with the external sodium concentration in a way which showed that the inward current was carried by sodium ions. These observations were followed by the discovery that the action potential was generated by the influx of sodium ions in muscle as well as nerve.

Hodgkin, Huxley and Katz studied the relationship between current and voltage in the nerve membrane. The currents were shown to be due to alterations in the permeability of the membrane to sodium and potassium ions, which were caused by changes of potential and accounted quantitatively for the propagation of the nerve impulse.

Through Hodgkin's researches we know that the rising phase of the nerve impulse (−70 to +40 mV.) is due to the influx of sodium ions, 3 $\mu\mu$moles/cm.^{2} nerve membrane/impulse at 15° C., sodium ions being pumped out of the resting nerve ; that the recovery phase (+40 to −70 mV.) is due to the efflux of potassium ions ; and that there is a compensating influx of potassium ions during the slower, metabolic, phase of recovery. Hodgkin and Keynes measured the sodium and potassium fluxes in both directions across the nerve membrane and showed that both were active processes.

All Hodgkin's work is elegant, conclusive and clear. He has applied new physical methods to biological problems and made quantitative measurements at every stage. It is largely owing to his work and influence that coherent and well-supported evidence now exists for the mechanism of nervous conduction.

Davy Medal : Prof. R. G. W. Norrish, F.R.S.

Prof. R. G. W. Norrish is distinguished for his many notable contributions to physical chemistry, particularly in the fields of the elucidation of photochemical change, the combustion of hydrocarbons and the development of experimental methods for the study of rapid reactions.

His early investigations of the catalysis of the intrinsically important reactions of the combination of hydrogen and chlorine and hydrogen and oxygen considerably clarified many features of these reactions. The general acceptance of the chain nature of these reactions, and the wider recognition of the occurrence of chain reactions led him to explore the mechanism of the photochemical dissociation of complex organic molecules, particularly the aliphatic ketones, and also to embark upon a considerable series of studies of the thermal and photochemical oxidation of hydrocarbons and related substances. These researches were of outstanding value in the understanding and interpretation of chain reactions.

Norrish then took up the study of the complex processes of addition polymerization and in this field he has made significant contributions. He and his co-workers were among the first to recognize the now well-known 'gel effect', and to elucidate the kinetics of copolymerization and the features of heterogeneous polymerizations. The ultimate development of Norrish's interest in the study of atom and radical reactions was the development and utilization of a high-intensity flash discharge lamp for the study of fast reactions. This method of 'flash photolysis' has become one of the most important techniques for this kind of work, and among other applications the method has been used successfully in the measurement of the spectra of new radicals, the study of rate of atom reactions and the investigation of explosive phenomena.

Darwin Medal : Sir Gavin de Beer, F.R.S.

Sir Gavin de Beer has made many contributions to the study and understanding of evolution. He early perceived that the mechanisms of individual development, at all stages from egg to adult, have an important bearing on evolutionary theory and that they must be taken into account equally with the facts of palæontology and comparative anatomy in framing a picture of the actual course of evolution.

Haeckel's famous theory of recapitulation asserted that the individual in its development ran through the successive adult forms of its ancestors, and that accordingly phylogeny in some way determined ontogeny. De Beer, in his "Embryology and Evolution" and successive editions of his later book "Embryos and Ancestors", has done more than any other biologist to show that Haeckel was wrong—that recapitulation, if present, is always the recapitulation of ancestral developmental stages, not of ancestral adult forms ; and that it is changes in ontogeny and its mechanisms which actually influence the course of phylogeny, and not vice versa.

In particular, he generalized the important concept of paedomorphosis, by showing how various types of retardation of various ontogenetic processes would result in the prolongation of juvenile characters into the adult phase. He thus demonstrated the importance of this anti-recapitulatory process for many notable evolutionary events, including the origin of insects from myriapods, and our own origin from an anthropoid stock.

For these studies he drew largely on his wide knowledge of experimental embryology, summarized in his joint volume with J. S. Huxley in 1934, as well as on his own monumental study of "The Development of the Vertebrate Skull" (1937). From this latter work he drew the conclusion that the earliest vertebrates had bony skeletons, and that the formation of cartilage was originally limited to the early stages of ontogeny. The cartilaginous skull of elasmobranchs is thus not ancestral, but neotenous, resulting from the prolongation of an embryonic condition into adult life and not from the recapitulation of an earlier adult condition.

In 1947, by his ingenious work confirming the origin of the urodele visceral skeleton from cells of the neural crest, he helped in finally burying the germ-layer theory in its original dogmatic form.

With equally ingenious methods, as director of the British Museum (Natural History), he was able to discover important new facts about the brain and breastbone of that precious fossil, *Archaeopteryx*, and to demonstrate that it was still incapable of manœuvrable flight.

Sylvester Medal : Prof. M. H. A. Newman, F.R.S.

Prof. M. H. A. Newman's work can be described under three headings :

(1) *Fixed point theory and continuous groups.* In 1900 Hilbert proposed the problem of showing that the analytic character of a continuous group follows from its continuity alone. This was proved by Brouwer for two-dimensional groups in 1910. In 1931 Newman proved it for commutative groups of arbitrary dimension. In this proof the basic lemma is that such a continuous group does not have arbitrarily small sub-groups. The proof of the lemma depends on an investigation of the fixed points of periodic transformations.

The later work of Newman on Hilbert's problem was not published and was rediscovered independently by Montgomery, Zippen and Gleason, who extended the basic lemma to non-commutative groups and gave a final solution to Hilbert's problem in 1952.

His most striking recent result was an elementary proof of the formidable fixed-point theorem of Cartwright and Littlewood.

(2) *Pure combinatorial topology.* This is the very difficult part of topology in which continuous mappings of manifolds are replaced by combinatory transformations of finite cell complexes. In 1926, Newman gave new life to this subject by completely refounding pure combinatorial topology using simplicial complexes and a new system of elementary combinatory moves. He showed the effectiveness of the new methods in a series of ten papers in which several famous problems were solved. All later work on the subject is based on Newman's results.

He ceased systematic publication on this subject in 1932, though he is known to have continued working on the conjecture of Poincaré and Steinitz that every manifold can be represented as a simplicial complex and that homœomorphic manifolds are simplicially equivalent. Interest in pure combinatorial topology has revived in the present decade since Moise, using methods similar to those of Newman, has proved the Poincaré and Steinitz conjectures for three-dimensional manifolds.

(3) *Applications of combinatorial methods.* After 1932, although very little of Newman's work on topology was published, he continued to publish a number of papers on logic, lattices and other applications of combinatory methods. He also published an important introductory text-book, "The Elements of the Topology of Plane-Sets of Points".

In 1941 Newman published a remarkable axiom system for Boolean algebra, and in 1943, in a paper on stratified systems of logic, he developed a general method covering the different type theories proposed by various mathematical logicians.

Hughes Medal : Prof. E. N. da C. Andrade, F.R.S.

Prof. E. N. da C. Andrade's experimental investigations have covered a wide field of physics. He elucidated the mechanism of a series of classical phenomena in sound. He demonstrated the method by which sand particles on a vibrating plate are brought to adopt the observed positions, the causes of the peculiar arrangements of the particles in the Kundt's tube, and the reasons for the characteristic behaviour of the sensitive flame. In the Kundt's tube he obtained experimentally the slow circulation predicted by Rayleigh, but not previously observed. Further, he has made considerable contributions to the domain of viscosity of liquids, including liquid metals; and to metal physics, including the properties of single crystals.

Andrade has derived a formula for the variation of viscosity with temperature. He has also derived a formula which gives the viscosity of a liquid at the melting point as a simple function of the atomic weight, density and temperature, free of any arbitrary constant. This formula has been used with success to predict the viscosity of liquid helium. His formula for the variation of viscosity with pressure yields exact agreement with the observed value of the only available monatomic liquid, mercury, at a pressure of 12,000 atmospheres. Andrade has also established the (very small) effect of an electric field on the viscosity of a liquid, an effect which had been vainly sought for more than sixty years.

In metal physics Andrade has done much original and ingenious work. In the investigation of creep he has shown the importance of maintaining constant stress instead of constant load, as was done by earlier workers in this field, and has given various mechanical methods for maintaining constant stress. He has established the laws of creep, dividing the process into two distinct parts, a temporary and a permanent creep, the first due to slip on crystal planes within the crystals, the second or permanent flow, which is important at high temperatures, being due to relative movements of the grains as a whole. The relative importance of the two forms of creep has been shown to depend on the temperature relative to the melting point. His early work on creep is considered fundamental in recent books on the subject.

Andrade has also developed methods of making single crystals of metal, in the form of wires or rods, and has investigated the nature of the glide planes. It was he who first established the 'easy glide' which can take place with cubic crystals, while a recent paper with Aboav extends the earlier work of Andrade and Henderson in which the 'easy glide' was established. Andrade also demonstrated the effect of surface conditions on the properties of metals.

SOME MODERN SCIENTIFIC THEMES

If, as some of us believe, natural science is to-day the foremost of humane studies, we cannot be indifferent to its great central themes: the nature of the cosmos, the origin in time of its present ordering, the law (cyclic or otherwise) of its evolution, the stuff of which it is made; waves, particles, and their ways, their mutual relations and their metamorphoses; the genesis of the chemical elements; the operation of the laws of chemistry and physics to determine the spectacle of material vicissitude; the origin of life, the evolution of its multitudinous forms, the manifestation of its properties and the correlation of these with the physicochemical principles which somehow underlie them.

In the scientific literature of a limited period the main lines of progress are not easy to make out. Occasional great discoveries burst on us like revelations, but mostly only trends are visible. The different contributions, moreover, are often expressed in quite different idioms, some indeed being scarcely intelligible except in the language of specialized symbolisms. Yet it behoves us to try to see where science stands and where it is going, and from this point of view I shall refer briefly to some of the trends and characteristics of the work of the very recent past.

Cosmology is in a state of flux in almost every possible sense. The present order of things, it now appears, has lasted something like 10^{10} years. Evidence from the 21-cm. radiation of hydrogen revealed the spiral structure of the galactic system, and now our estimate of the whole scale of the stellar universe has suddenly been enlarged by the observations of Sandage. The 200-in. telescope has during the past year revealed that some distant objects thought on the evidence of the 100-in. instrument to be stars are in fact associations, and in consequence the accepted distance scale must be greatly increased, according to one line of argument by a factor of several times.

The radio telescope is contributing much to work on the structure of the universe, and the past year has seen major advances in technique. The possibility that some of the radio sources may be colliding galaxies beyond the range of optical telescopes shows the significance of the new methods. It may also be hoped that observations, from artificial Earth satellites, of radiation in wave-lengths absorbed by the Earth's atmosphere, may lead to further discoveries about the happenings in the depths of space. This is perhaps one of the best of reasons for launching these bodies.

Our general conceptions have long been largely dominated by the apparent continuous expansion inferred from the infra-red shift of spectral frequencies. This recession of nebulæ was recently interpreted by Holmberg in terms of a special geometry where velocity and position are complementary quantities and where the equations provide that what is interpreted locally by one observer as displacement is interpreted by a distant observer as velocity.

How much value we attach to translations into geometrical formalism really depends upon a philosophical attitude. The earliest great synthesis of Nature, the theory of gravitation, later received a famous geometrical interpretation in the general theory of relativity. But other explanations based on the particle-exchange conception familiar in chemistry and nuclear physics have been sought, and have very recently been revived, with the neutrino in the role of the binding particle. The outcome is uncertain but it would be æsthetically satisfying if, as it were, the infinitely great and the infinitely small were thus brought into relation.

According to some theories, there is an endless renewal of cosmic cycles, determined by extremely rare collisions between stars: new galaxies are formed from the debris of old, new stars are born and the chemical elements are rebuilt from the undifferentiated nuclear matter of hyperdense stars. However this may be, cosmology and nuclear physics here come into strikingly close relation. A reasonably plausible though complex set of hypotheses is emerging about the manner in which the chemical elements are formed by 'hydrogen burning', 'helium burning' and by neutron capture processes in the stars. The details depend largely upon the evidence of nuclear collision processes studied in the laboratory, and on calculations based on the results. In spite of all uncertainties and complications, a most impressive picture emerges of the origin and relative abundance of the elements.

In contrast with the abstract formalism of parts of the theory, it is interesting to note in nuclear chemistry and physics generally how much is still being done in a relatively simple manner. Nuclear syntheses, at temperatures of the order 10^8 deg. K., are treated in a way resembling on a vastly magnified energy-scale the familiar calculations of chemistry. The synthesis of carbon-12 from three α-particles, to take one example, is envisaged as occurring in the steps:

$$2\alpha + 94\,\text{keV.} = {}^{8}\text{Be}$$
$${}^{8}\text{Be} + \alpha + 278\,\text{keV.} = {}^{12}\text{C}^{*}$$
$${}^{12}\text{C}^{*} = {}^{12}\text{C} + 2\gamma + 7{\cdot}65\,\text{MeV.}$$

and the rate of the reaction is estimated by an integration of the Maxwell energy distribution of α-particles over each of the relevant resonances.

Theories of this kind, like the planned synthesis of isotopes, have something of the character of structural chemistry in its heyday; and indeed a whole chapter of nuclear chemistry dealing with synthesis, fission and so-called spallation reactions operates in terms of quite elementary ideas, odd or even numbers of neutrons and protons determining stability and frequency of occurrence of nuclei, and the likelihood of their fission after neutron capture. It is interesting to note in passing that recent estimates, based upon reasonable extrapolations, predict the possibility of nuclear masses a good deal higher than was at one time envisaged. The original synthesis of element 102 has been called in question, but a new production by a different method is simultaneously claimed. (Even this situation has echoes of the classic days of synthetic organic chemistry.)

Reduced to its simplest terms, the project of harnessing the energy from nuclear fusion in the reactions D + D or of D + T is the old problem in reaction kinetics of raising gases to an ignition temperature, where the heat evolved from reaction exceeds that needed to provide the activation energy and balance the losses. Temperatures of nuclear transformations are about six orders of magnitude greater than those of ordinary chemistry. Thus what is now being brought near to realization is the application of advances in electrical engineering to render possible in the laboratory what a few years ago appeared possible only in the stars.

The translation of traditional physical chemistry far up the energy-scale raises an interesting speculation. In certain chemical reactions, branching chains lead to the existence of critical pressures where abrupt transitions from slow reaction to explosion occur, and the same pattern exists in the phenomena of critical size in nuclear fission. In chemical systems special conditions are known where the branching and quenching of chains give rise to periodic flames. It is an interesting question whether perhaps eventually the chain reactions of stellar alchemy may even explain in an analogous way the mystery of the Cepheid variables.

One of the profoundest problems facing science to-day remains that of the so-called elementary particles themselves. The subject is no easy one, and throughout its description the abstractly formal and the naïvely pictorial interplay with curious contrasts. The entities in question are, in fact, neither elementary nor in the usual sense particles, yet in some way they, or some of them, are the stuff of which everything is made.

Even in the bizarre and scarcely credible world of mesons, neutrons, hyperons, 'strange' particles and the like, there occur phenomena still oddly reminiscent of the simpler kinds of chemistry. 'Positronium' is now known in its *ortho* and *para* forms; mesonic atoms have been detected. Mesons can be made to function as catalysts for nuclear reactions, as, for example, in the bubble chambers where there occurs the reaction (Jackson 1957):

$$\mu^{-} + p + d \rightarrow {}^{3}\text{He} + \mu^{-} + 5{\cdot}5\,\text{MeV.}$$

with a mesonic atom as a probable intermediate. Another example of the relatively simple analogy is to be found in the so-called shell model of the nucleus, which has been yielding useful results by methods not unfamiliar to the spectroscopy of a generation ago. Reactions provoked by the antineutrino flux from the β^{-}-active fission products of a uranium-235 pile provoke reactions such as $p(\bar{\nu}, \beta+)n$, in striking vindication of what once used to seem a mathematical fiction.

Yet the homely analogies fail when confronted with the attempt to interpret the nuclear particles themselves, and the physics of their generation, mutual interaction and decay. Some completely new principle, it seems, is needed before this subject assumes the form of a coherent and intelligible body of doctrine.

More and more remarkable facts are being revealed, largely by the technique of scattering experiments, carried out with the aid of the great accelerating machines. The principle is a simple one, beams of particles of the appropriate character being passed through a material presenting an array of obstacles, such as electrons or nuclei. What may crudely be termed collisions occur, and the incident beam is replaced by an attenuated transmitted one together with a scattered beam, the intensity, character and angular distribution of which is determined. It is in this, as well as in the arrangements for the generation of the beam, that varied and ingenious, elaborate and costly methods are called for. The theoretical treatment of these problems is based upon the equations of quantum mechanics and necessarily assumes an abstract and formal character. The density of particles in the incident beam is represented as a function of the spatial co-ordinates by one wave, that of the scattered beam by another. The relation between the two involves, apart from certain general requirements of continuity, the function representing the potential energy of the interaction between the two kinds of entity concerned in the collision. This function for various kinds of interaction is one of the main objects of research, and its determination depends upon complicated and often subtle characteristics of the intensity distribution. Enormous effort is being expended on this problem, but a satisfying theory of nuclear forces is still lacking.

In the curious picture of tidiness and complexity which nuclear particles present, the element of symmetry, so strikingly extended by the discovery of the antiproton and the antineutrino, has been strengthened by the appearance of the antineutron, which is produced in the process:

$$\text{antiproton} + \text{proton} \rightarrow \text{neutron} + \text{antineutron}$$

The antineutron, like the neutron, has no charge, but differs from it in that its magnetic moment is parallel instead of antiparallel with its spin angular momentum.

Questions of spin and symmetry, though belonging to the abstract rather than the naïve modes of interpretation, can be more vividly apprehended than most of the former group and are clearly fundamental to the nature of things. The problem of the conservation of parity has naturally roused much interest, and this subject formed the theme for a Royal Society discussion meeting early in the current year. Despite the rather deep significance of the parity question, it seems to be agreed that the practical consequences in physics of the non-conservation are much less drastic than other failures of conservation might be.

Thus by minute but immensely significant brush strokes the grandiose picture can be seen slowly emerging. The abstruse bombardment and scattering experiments of physics probe at the secret of the strange and often transient microcosmic entities while the 200-in. telescope and the radio telescope, presently perhaps to be reinforced by instruments carried by satellites, penetrate the depths of space to find the secrets of the macrocosmic entities. Within the greater entities, the lesser, under the impulse of almost Pythagorean laws, yield the chemical elements, and the greater, themselves transient on their own vast time-scale, evolve planets, where organic substances can be synthesized and life appears.

In the second half of last year the Moscow conference on the origin of life brought to focus a further series of interrelated problems. Cosmology and geology determine the initial possibilities, which depend upon the original terrestrial atmosphere. This probably was a reducing one containing methane, ammonia and hydrogen, from which amino-acids, and by stages a complex store of organic compounds, could be accumulated. According to one view, there must have arisen at some stage self-reproducing mechanisms within semi-liquid colloidal systems, a process not necessarily dependent on enormous improbabilities, since it could occur in stages, prefabricated units of one order of complexity uniting to give constellations of a higher order.

Once living material has been formed, natural selection operates on it. In the centenary year of the historic paper of Darwin and Wallace, this principle is not likely to be forgotten. It has long dominated biology, and in one form or another is incontestable. Heritable mutations or new combinations leading to a finite advantage will of course prevail. Too often, however, people have been content to leave it all at that and to treat the real problem as though it did not exist. What is the nature of a mutation, and, a much profounder question, by what means does it express itself in the organism ? We cannot be content with vague assertions that the possibilities of life are infinite. Selection presupposes something worth selecting; in a war-time market the shopping capacities of the best housewife are of little avail.

Recently the custom has grown of speaking of codes or programmes contained in the structure of the deoxyribose nucleic acid of the cell. Vast macromolecules composed of alternating sequences of varied units can, evidently, in their permutations and combinations, provide a code for anything. After all, the twenty-six letters of the alphabet can express the whole of human knowledge. But at least as important, and much harder to visualize is the working of a machine to translate the code. The interrelation deoxyribonucleic acid – ribonucleic acid – protein governs the growth of the cell, with its enzyme complement and characteristic reaction pattern. The relation of the cell to the tissue, and of the tissue to the organized plant or animal, is not, after all, made much easier to understand simply by the principle that efficient self-replicating systems once established will displace less efficient ones.

The sequence of events by which the genetic code is operated is highly complex, and at certain stages of it there might be crucial points such that a small change in the code directs development along widely different paths. A phenomenon of this kind would perhaps satisfy the need of those who have felt some doubt, not of the truth and efficiency of natural selection, but of its ability to say everything that is worth saying about the origin of species. No metaphysical principles, of the kind rightly deplored in science, are involved in asking whether a certain discreteness in species may not be inherent in a corresponding discreteness in the admissible solutions of the equations which relate the possible growth-forms of an organism to the basic genetic pattern. Discontinuities arise in analogous ways throughout chemistry and physics.

The working of the machine by which genetic information is translated into cells and into complex individuals and by which it determines species is thus really the central problem of biology. The problem is being studied at many levels, and in many ways ; by work on the basic chemical structures themselves, on changed amino-acid sequences in the proteins of mutants, on the persistence of biochemical functions in living material after disintegration of entire cell structures, on the separation and reconstitution of virus components, on interference with virus growth, on the unbalanced growth of cells exposed to abnormal conditions, on adaptive phenomena in intact cells, on the earliest stages of embryonic development, including the effects of chromosome defects and of nuclear transplantation.

Naturally enough, much interest centres in the nucleic acids themselves. There is no question of the importance of their pattern, though even here it would seem to be unfortunate if exclusive preoccupation with this one aspect condemned to neglect all the other aspects of cell organization and structure Indeed, in connexion with virus reproduction, Fraenkel-Conrat, Singer and Williams concluded tentatively that "the protein may after all have a minor influence in the replication process". It would indeed be surprising if anything short of the complete structure and the entire organization of a cell completely determined its reproduction.

In seeking to fit the individual pieces of the specialized literature into their places in a coherent pattern, a classification into those dealing primarily with form and those dealing primarily with function may be made as a matter of rough convenience.

Pure form is illustrated by the many chemical studies on the structure of nucleotides, nucleic acids polypeptides and protein which are made by physical and chemical methods, both analytically and synthetically. As recent examples out of many, I might quote on one hand the synthesis of peptides containing sequences found in the natural compound argenine vasopressin, and on the other a hypothetical establishment of the complete amino-acid sequence i glucagon (a material of pancreatic origin).

Function can be studied in many ways. One is the careful observation and interpretation of the behavi our of intact cells in growth and adaptation. Another is the detailed study of individual enzymes and their 'induction' (Monod, Pollock). Such work has been widely discussed in recent years. Lately, much attention has been given to methods which seek, as it were, to analyse the function of the cell into single elements. One is by the investigation of the biochemical potentialities of cell extracts, and cell fragments, mitochondria, protoplasts and so on, and of the related question of 'metabolic pools' in cells. Cells can be broken down by various methods, by the use of lysozyme, sonic vibrations, various grinding procedures and by centrifugation which separates particles of different sizes from cell walls and supernatant fluid. The enzymatic functions of different fractions can be tested, and the relative proportions of different constituents in the various fractions determined. The localization of functions in the various size-ranges appears to vary with the organism studied and with the technique of disintegration employed. Sometimes a given function is shown predominantly by one fraction, for example, the supernatant fluid left after centrifuging, sometimes by several fractions. These and other complex observations obviously bear upon the question of internal organization in an important way, though almost any conclusion of general interest rests upon some very specialized and detailed judgment about the significance of given elements in the technique.

One observation of great interest is that of Roberts and collaborators, who find that a clear preparation of certain cellular juices to which manganous ions are added may, after a period of delay, give rise to particles (to which the term 'protomorphs' is given). These possess variable synthetic ability and seem to represent an intermediate state between the organization of the cell and the disorganized condition of the juice. As another example may be quoted the observation (Utter, Keech and Nossal) that yeast cells contain sedimentable subcellular units which have enough organization to effect complete biochemical reactions.

These and many other observations show that the organization of the cell is departmentalized and perhaps in a hierarchical manner, protein and nucleic acid being in a structural relation within particles, and particles themselves forming structural arrays in the cell. There is, however, a limitation to this approach. If a factory capable of manufacturing entire motor-cars were bombed it might be capable soon afterwards of turning out engines but not chassis or vice versa, or the electrical supply might be intact and the water cut off, and so on. Much could be inferred from careful observation, but nothing would really replace a study of the working of the intact installation.

Intact cells studied under abnormal conditions have yielded very valuable observations, of which I can quote only a few. In the presence of certain drugs protein synthesis may be held up while ribonucleic acid synthesis continues. In one system it was found (Ben-Ishai) that if ribonucleic acid is formed without protein, and then protein synthesis is allowed to occur afterwards, the preformed ribonucleic acid does not participate in this synthesis, which is linked only with that of the deoxyribonucleic acid simultaneously made. Certain mutant bacteria studied by Cohen required thymine and will not multiply in its absence, being unable to synthesize the deoxyribonucleic acid necessary for cell division. They may, however, form protein and ribonucleic acid, and the resulting unbalanced growth may eventually prove lethal. If the mutant also requires a specific amino-acid, withholding this restrains the unbalanced growth and increases the ultimate survival. A strain requiring both thymine and phenylalanine was incubated first in phenylalanine without thymine and then vice versa : something occurred in the first stage which permitted in the second stage a doubling of the deoxyribonucleic acid without formation of ribonucleic acid—an elegant example of control. A somewhat similar control operates in the process whereby cells from which thymine is withheld can be brought into a state where addition of thymine will cause all to divide together, a 'synchronization' process, which had been earlier effected by manipulation of the growth-temperatures of cells.

Division is largely determined by deoxyribonucleic acid. Deoxyribonucleic acid is the most important seat of hereditary characters. What may well be an enlightening glimpse of the first stage in the translation of the code is provided by the work of Holt and his collaborators. By special staining devices they locate areas of specialized enzyme activity in the cell. In rat-liver cells, enzymes having normally a peripheral distribution gather together during the process of mitosis and cluster towards the nuclear region, themselves going through a characteristic series of movements before dispersing finally to the surface regions of the daughter cells. This intimate communion of enzyme material with the nucleus during the mitotic process is an impressive reminder that the cytoplasm should not be regarded as an inert passenger without significance in reproduction.

Proteins and nucleic acids, genes, chromosomes and nuclei, cells, and early embryos are thus yielding suggestive glimpses of the fundamental mechanisms of the biological machine. Further clarification calls perhaps for a little more boldness in the study and analysis of hypothetical models, though in parts of the subject some of these are indeed being tested. Models in the more fundamental parts of physics are out of fashion, perhaps gone for ever, but in biology they remain a powerful aid ; not only in the chemistry and physics of cells, but also throughout physiology, up to the working of the nervous system and the operation of the brain itself.

Of brain function there is a crude and distant, but fascinating, reflexion in the operation of electronic calculators. In one of the latest of these, constructed by Uttley, statistical information about the pattern of input activity is accumulated, a leakage device ensuring that recent events have a greater influence than earlier ones. The result is that the machine operates in a way which in everyday language can be likened to learning by experience. The comparison may not prove to be a valid one, but it is even more interesting and provocative than anything I have yet seen in discussions about the other end of the scale, where the nucleic acids first begin to direct the development of any living organism.

So from the abysses of space where the elements are evolving and worlds are forming to the human brain which thinks about it all the story is unfolding. No detail of it is won without expert labour much of which is beyond the power of the layman to judge. But let us not forget the ends to which it is directed. It is all too easy to think of detailed and absorbing work as an end in itself ; but in so far as we may yield to the temptation, science will fail to occupy that place in the scheme of things which is its rightful due.

MOTILITY OF THE SPERM FLAGELLUM

By Dr. DAVID W. BISHOP

Carnegie Institution of Washington, Baltimore

SIR JAMES GRAY has admirably analysed the nature of the complex pattern of flagellation in the spermatozoa of the sea-urchin and the bull[1,2]. In both species of sperm a co-ordinated activity involving two major components of motion has been indicated—a propagated uniplanar wave initiated at the proximal end of the flagellum, and a superimposed longitudinal rotation upon the axis of propulsion due to a third-dimensional thrust by distal elements of the tail. The roughly helical pathway which results, albeit a tight spiral, is thus inherent in flagellar activity. It is not to be attributed, for example, merely to an asymmetrical configuration of the sperm head, which might convert a simple two-dimensional beat into an apparently three-dimensional movement of the entire cell.

The relation of mechanics of rotation to propagation of the vibrational wave appears to be quite different in these two types of sperm. Longitudinal spinning in sea-urchin sperm occurs at the rate of about 3/sec., whereas the vibrational wave-frequency averages 33/sec.; the two are thus relatively independent. In bull sperm, on the other hand, the rate of rotation corresponds closely to the frequency of the bending waves, 8–9/sec., and the two therefore seem interrelated. It was suggested that the bull sperm undergoes rotation as a result of a slight twist in the tail where the bending wave passes over the distal region. An alternative explanation was that a torsional wave accompanies the bending wave in its propagation along the flagellum[2].

The ultimate elucidation of these and other details of sperm motility will, of course, have to await further morphological clarification of the ultrastructure of the cell, particularly that afforded by the electron microscope. An explanation of the mechanics of movement will also depend on the biochemical identification of the precise elements involved in the processes of contraction, compression, and co-ordination of the flagellum. However, certain current observations of sperm, admittedly subject to highly unorthodox procedures, have some bearing on this problem and constitute the substance of this article. The two modalities of movement, indicated by Gray, can be separated and, in a sense, analysed individually. Their 'uncoupling' permits a consideration of the mechanics of waves as opposed to the propagation and co-ordination of waves. At the risk of attempting to tie up too much in one bundle, a tentative and simplified hypothesis of sperm flagellation is suggested.

The motility of spermatozoa, freshly exploded from the spermatophores of the common squid, *Loligo pealii*, is characteristically a violent, lashing, three-dimensional phenomenon. When such preparations are allowed to age, changes in motility, as might be expected, are pronounced. Sperm activity is very much decreased, as is fertilizing capacity; in this sense the cells are pathological. Nevertheless, with this caveat well in mind, we have found their slow motion to be a useful subject for study since they are not so seriously impaired that they cannot clearly respond, by a prompt increase in motility, to the addition of adenosine triphosphate in sea water.

In such slowly moving spermatozoa two kinds of movement may be readily distinguished. The more vigorous activity consists of a two-dimensional bending wave, asymmetrical with respect to the longitudinal axis and limited to the proximal segment of the flagellum (Fig. 1). The duration of wave formation compared with that of wave dissipation is of the order of 3 or 4 to 1, with a perceptible pause between beats. Bending, presumably the contraction phase, thus occurs gradually; straightening, the corresponding relaxation phase, occurs abruptly. Such wave formation can occur rhythmically without propagation along the flagellum. This uniplanar vibration may or may not be accompanied by the rotational movements discussed below.

Of the cells which could be clearly observed to undergo this slow-paced steady rhythm, fully 80 per cent bent in the plane and in the direction of the mitochondrial spur, a prominent characteristic of the mid-piece of the squid sperm. Thus, a relation exists between the asymmetry of the cell and the orientation of the vibration. The structural correlation of the spur with the ultrastructure of the axial bundle, and the additional correlation of the fibrillar arrangement with respect to the direction of beat of the flagellum bear further investigation. A relation of fibrillar orientation to direction of beat has indeed been established for cilia[3], and suggested for sea-urchin sperm[4].

The second and less-vigorous type of motility seen in ageing squid sperm is a rotation on the longitudina axis at the rate of 3–4 revolutions per second. This movement is generated by the distal region of the tail and, as in the sea-urchin sperm, the rate is very much lower than is the frequency of distal flagellation Spinning may occur in straight, otherwise motionless sperm as well as in those cells which also display the vibrational wave. The direction of rotation, which can be observed by virtue of the projecting spur, is predominantly counter-clockwise, viewing the sperm head-on (Fig. 1).

Thus, in these retarded squid sperm, motility, while far from the co-ordinated rapid movement of normal cells, proves to be basically similar to that recorded for sea-urchin sperm[1]. An added feature concerns the close correlation of the plane of two-dimensiona vibration with the gross asymmetry of the mid-piece

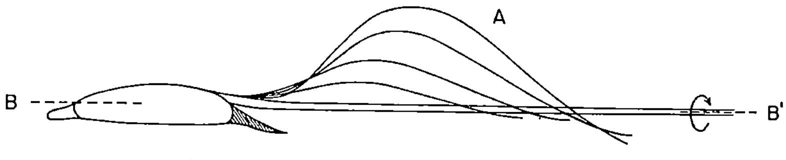

Fig. 1. Components of squid sperm motility. (1) Two-dimensional bending wave, *A*, initiated proximally, parallel to plane of mid-piece spur (cross-hatched). (2) Rotation upon longitudinal axis, *B–B'*, generated by distal region of flagellum

of the squid sperm. The significance of the difference in direction of rotation is not clear.

Certain aspects of sperm motility can be analysed in a totally different way—again of sperm exposed to highly unorthodox but controlled procedures. Sperm of several species of mammals (rabbit, rat, mouse, guinea pig, bull and man) have been prepared as glycerine-extracted cell models[5] comparable with the muscle-fibre systems introduced by Szent-Györgyi[6]. Such models have presumably lost all soluble inorganic and organic substances, their permeability has been destroyed and their ionic balance upset; the contractile and structural proteins, however, prove to be functionally intact. These models, parenthetically, are morphologically normal as seen in the phase microscope. Unlike muscle-fibre models which contract only once upon the addition of adenosine triphosphate, sperm models assume a persistent rhythmic activity which lasts many minutes or hours; in a very real sense, the contraction–relaxation cycle is self-perpetuating[7]. The flagellation is frequently as vigorous and may even exceed the frequency of beat of fresh sperm. Wave amplitude approximates that of normal vibration, 6–8μ. The entire tail can be involved or only short segments located proximally or distally along the flagellum. Bending waves develop from both sides of the longitudinal plane, implying the presence of contractile elements along both sides of the tail. Two limitations, however, distinguish the motility of sperm models induced by adenosine triphosphate from that of normal cells. The models show neither wave propagation along the flagellum nor rotation upon the longitudinal axis. Moreover, they fail to undergo any significant forward progression, despite the vigour of their movements.

The study of such extracted sperm models leads to the conclusion that, while inherently generated bending waves similar to those of normal contraction–relaxation cycles occur, both wave propagation and co-ordination are absent. Repeated efforts to restore these missing elements to the motile process by adequate adjustment of the ionic balance have been quite unsuccessful.

What emerges, then, from observations on such aberrant cells in relation to motility in normal spermatozoa ? Confirmatory evidence is provided for the existence of two discrete components of flagellation. Wave formation, as a mechanical and chemically generated process, is distinct from wave propagation and co-ordination leading to helical motion. The energy for vibration is distributed along the flagellum and distal oscillation does not require visible proximal wave bending. Bending couples may involve only segments of the flagellum; there is no evidence to indicate that a tensile element, extending throughout the tail, must contract in its entirety, whether this be visualized as a straight or a twisted fibril system[8]. Wave formation normally seems to be initiated at the basal corpuscle or mid-piece and to travel distally in a propagated manner.

Should rotational activity depend on a twist in the contractile or in the compressive elements of the tail, the twist must be sought in the distal region of the flagellum. If the distal helical flagellation depends on co-ordination from the proximal end, this conductile system may be lost altogether concomitantly with failure of wave propagation (for example, sperm models), or may persist despite the absence of a propagated vibrational wave (for example, squid sperm). In both types of sperm, however, the rate of terminal flagellation is high, the slow roll of the squid and sea-urchin sperm being a false index of the frequency of oscillation.

To what extent are these findings consistent with the ultrastructural picture of the sperm ? The more recent electron microscopic investigations of spermatozoa indicate that the fibrillar arrangement of the flagellum is more complex than that represented by the well-nigh universal, simple 9 + 2 or 2(9) + 2 system of longitudinal filaments[9–11]. Superimposed upon the basic radial symmetry is a bisymmetry provided by the two central filaments and the individual differentiation of the peripheral fibrils[12,13]. Such an arrangement, most prominent proximally, affords a physical basis for envisaging an oriented vibration in a single morphological plane, a wave characterized by a prevalent direction of effective beat and asymmetrical bending. The elegant electron micrographs of sea-urchin sperm tails prepared by Afzelius further suggest that cross-links ('side arms' and 'spokes') may connect adjacent peripheral fibrils and interconnect these with the central pair[4].

The contractile elements are generally regarded as located in the nine peripheral double fibrils of the flagellum. Evidence for this is largely circumstantial, but nevertheless considerable[4,9,14,15]. The function of the two central fibrils is somewhat in doubt, but they are to be regarded as relatively rigid supports and mainly responsible for the determination of the direction of vibration[4]. The structure and function of the cytoplasmic 'matrix' and of the prominent fibrous sheath, or 'cortical helix', of mammalian sperm are also poorly understood. Judging, however, from the gradual taper from proximal to distal end of the flagellum of many kinds of vertebrate sperm, from the relative nakedness of the terminal region of some flagella, and from the obvious differences in bending characteristics from fore to aft[1,2], the resistance to oscillation appears to decrease with passage of the propagation along the tail to the tip.

Any hypothesis of sperm motility at this time can be only tentative at best; nevertheless, sufficient information is available to project an intracellular system along the following lines. Flagellation is due to a series of rhythmic contraction–relaxation cycles performed by the activity of contractile proteins comparable to those of muscle. Locomotion results from a combination of two discrete components. (1) Two-dimensional waves initiated proximally in the region of the basal corpuscle are self-propagated distally. All or some of the nine peripheral fibrils respond, but the fibrils of maximum effective bending (for example, Nos. 5 and 6; cf. Bradfield[9]; Fawcett[3]) exert the most tension, or are stimulated most effectively, and establish the pattern of the bending wave. Each contraction wave is necessarily followed by a counterwave, out of phase, which passes down the other side of the axial bundle (for example, Nos. 1, 2 and 9). The interaction and the perpetuation of these successive contraction–relaxation cycles, as well as the events of the single contraction–relaxation cycle itself, are inherent in the biochemical properties of the contractile elements and are at present only poorly understood. (2) Three-dimensional rotational waves are generated by the distal region of the tail and are due to the other 'minor' peripheral fibrils exerting their influence relative to that of the 'major' fibrils responsible for the two-dimensional oscillation more proximally. The conversion of the two-dimensional bending couple to the three-dimensional spiralization is brought about by the spread or diffusion of the contraction stimulus through the cytoplasmic 'matrix' and would be facilitated, and possibly directed[9], by sub-fibrillar connexions if they should be shown to exist. The point that bears emphasis, however, is the suggestion that the same propagated disturbance may result in a two-dimensional vibration proximally and a three-dimensional spiral distally. In this respect, a torsional wave always accompanies the bending wave. Any decrease in the resistance or compressibility of the distal region of the tail would tend to increase the three-dimensional lashing of that portion of the flagellum.

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OBITUARY

Prof. Lewis Knudson

THE death occurred on August 31 of Prof. Lewis Knudson, emeritus professor of botany in Cornell University, Ithaca, New York. Thus ended an association with the New York State College of Agriculture at Cornell University which was in its fifty-first year.

Prof. Knudson was widely known for his work on the aseptic culture of orchid embryos, and his death will be regretted by botanists and plant physiologists around the world. Since his retirement from active teaching and administrative duties in 1952, at the age of sixty-eight, Prof. Knudson had retained his interest in his research, and, until a very short time before his death at the age of seventy-three, he daily visited the office and laboratory in which he continued to work. He is survived by his wife, two sons and several grandchildren.

The career of Prof. Knudson spans the history of plant physiology in the College of Agriculture at Cornell University, for in 1908 he came from the University of Missouri to work with Prof. Duggar in the then newly established Department of Plant Physiology. Dr. Knudson was to pass his entire and long career at Cornell University, from 1911 when he was awarded the Ph.D. degree, to 1916 when he became professor of botany in the newly constituted Department of Botany under Prof. K. M. Wiegand, to 1941 when he assumed the role of administrative head of the Department on the death of Prof. Wiegand, and until his retirement in 1952.

During 1919–21 Dr. Knudson spent a year in France, carrying out work at the Sorbonne, attending lectures at the Pasteur Institute, and he also gave lectures in Madrid and Barcelona. His interest in the problems of tropical agriculture took him many times to the countries of Central America.

The effect of the early formative years with Prof. Duggar was long evident and often referred to by Dr. Knudson, even in his later years. An early interest in fungi and in aseptic techniques permeated Prof. Knudson's pioneer work on the growth of whole plants under aseptic conditions, which in turn made feasible his early studies of their organic nutrition and the availability of various carbohydrates for growth. It also permeated his early influence on the growth of excised roots, his work on nitrogen fixation and the nodule-forming organisms, his studies on the germination and nutrition of orchid embryos, and his well-known investigations on mycorrhiza and the aseptic growth of plants which were previously regarded as essentially requiring the mycorrhizal fungus. Prof. Knudson's uses of both orchid embryos and *Chlorella* to study the facts of mineral nutrition are well known. This dominating interest in the use of aseptic culture methods in the study of plant physiological problems, or to study means of suppressing the growth of fungi as pathogens, survived to his death, for in this area of work his advice was continually being sought by industry. Although tissue culture procedures are now commonplace, and the use of uni-algal cultures is frequent in many types of physiological work, one has to recall that Prof. Knudson was among the earliest pioneers in the adoption of these methods. Less widely known, but still noteworthy, was Prof. Knudson's interest in the effects of radiation on chloroplast morphology in ferns.

Another salient characteristic of Prof. Knudson's work and interest was that he was always challenged by the research opportunities inherent in situations fraught with economic consequences. Among his earliest work was an investigation of fermentation processes in the difficult area of tannins ; he was challenged by, and often referred to, the commercial production of vanilla ; and even up to his death he was working upon a summarized account of the Panama disease of the Gros Michel banana in Central America, a problem to which he had devoted many years. Often far ahead of his time, many of Prof. Knudson's works paved the way so that later researches, made after knowledge and technique had advanced, flourished in areas that he had pioneered.

Perhaps best known for his work on the germination and growth of orchids, Dr. Knudson had a wide circle of correspondents. He advised many growers in his aseptic culture methods of raising embryos to whole plants. One correspondent, not known to him personally, touched him deeply in his later years when he acknowledged his work on orchids by sending an exact replica of an orchid flower set in silver. In 1956, the Federated Garden Clubs of New York State awarded to Dr. Knudson their Gold Medal, which had previously been awarded only to the distinguished botanist and horticulturalist and Dean of the College of Agriculture, Liberty Hyde Bailey.

Prof. Knudson's many friends and students, and those in science and industry who knew of his work, will deeply regret the termination of his long career as botanist and especially plant physiologist.

F. C. STEWARD

NEWS and VIEWS

Royal Scottish Museum: Dr. A. C. Stephen

Dr. A. C. Stephen, who is retiring from the post of keeper of the Department of Natural History in the Royal Scottish Museum, Edinburgh, was educated at the Edinburgh Institution (Melville College), Robert Gordon's College and the University of Aberdeen. He interrupted his studies to serve with the Royal Engineers in France and Belgium. For the last year of the First World War he worked as an assistant in the Department of Chemistry, Royal College of Science, London, on new poison gases and other problems. Returning to Aberdeen, he graduated with distinction in zoology, and for the next year acted as an assistant in the Chemistry Department, North of Scotland Agricultural College, Aberdeen. In 1920 he joined the scientific staff of the then Fishery Board for Scotland. Spending much time at sea, where during intervals in general duties he carried on a quantitative investigation of the bottom fauna of the North Sea with the newly designed Peterson grab, he later extended the survey to the sandy and muddy intertidal areas, investigating numerous portions of the Scottish coast. In 1925 he joined the staff of the Natural History Department of the Royal Scottish Museum, as assistant. He was appointed assistant-keeper in 1934 and keeper in 1935. He graduated D.Sc. in 1934. Besides papers on the intertidal and offshore surveys, he has published accounts of the turtles, cephalopods and Gephyrea of Scottish waters. He has also published accounts of the Gephyrea from many parts of the world, being a recognized authority on this group. As keeper, his principal task has been the care of the collections during the Second World War and the rehabilitation of the Department after the War. For a period he was also in charge of the Geology Department. Apart from his work in the Museum, he has taken part in outside scientific activities. He has been twice president of the Astronomical Society of Edinburgh, secretary and president of the Royal Physical Society of Edinburgh, a member of several councils and committees. During 1935–39 he was editor of the *Scottish Naturalist*. He also acted for a period as an examiner for the Museums Diploma.

Mr. A. R. Waterston, O.B.E.

Mr. A. Rodger Waterston, who is to succeed Dr. Stephen as keeper of the Department of Natural History in the Royal Scottish Museum, was educated at St. Paul's School, London, and the University of Edinburgh, where he graduated in June 1934 with first-class honours in zoology. He was awarded the Sir David Baxter scholarship in natural science and joined the staff of the Royal Scottish Museum as assistant keeper in the Department of Natural History in September 1935. On the outbreak of the Second World War he was seconded to the Ministry of War Transport and was District Transport Officer for Clydeside until 1942. After a year's service in the Royal Scots, he was transferred to the Middle East Supply Centre, Cairo, as locust officer in the Middle East Anti-Locust Unit, and took charge of the Palestine Anti-Locust Unit in Saudi Arabia. During 1945–46 he paid two visits to the Yemen to establish friendly relations and to introduce modern anti-locust campaigns there. He became chief locust officer of the Middle East Anti-Locust Unit in 1947, and from then until 1952 he was entomological adviser to the British Middle East Office and attaché for scientific affairs at the British Embassy, Cairo. His work was largely concerned with the building up of international technical co-operation and co-ordination of desert locust control work between the countries of the Middle East, Africa and India. He was made O.B.E. in 1952 in recognition of his contribution to anti-locust work in the international field. He resumed duties in the Department of Natural History at the Royal Scottish Museum in the autumn of 1952 and has since been engaged in the reorganization of the insect collections.

Royal Society: Officers

At the anniversary meeting of the Royal Society on December 1, Sir Cyril Hinshelwood was re-elected president. The other officers re-elected for the ensuing year were: *Treasurer*, Sir William Penney, director of the Atomic Weapons Research Establishment, Aldermaston; *Biological Secretary*, Sir Lindor Brown, Jodrell professor of physiology at University College, London; *Physical Secretary*, Prof. W. V. D. Hodge, Lowndean professor of astronomy and geometry in the University of Cambridge; and *Foreign Secretary*, Dr. H. G. Thornton, lately head of the Department of Soil Microbiology at Rothamsted Experimental Station. Other members of Council elected were: Dr. G. E. R. Deacon, director of the National Institute of Oceanography, Wormley; Sir Charles Dodds, Courtauld professor of biochemistry, University of London; Prof. G. Gee, Sir Samuel Hall professor of chemistry, University of Manchester; Dr. H. Godwin, reader in Quaternary research, University of Cambridge; Prof. L. Hawkes, emeritus professor of geology, Bedford College, University of London; Prof. R. D. Haworth, Firth professor of chemistry, University of Sheffield; Sir Christopher Hinton, chairman of the Central Electricity Generating Board; Prof. A. L. Hodgkin, Royal Society research professor; Prof. N. Kemmer, Tait professor of natural philosophy, University of Edinburgh; Prof. M. J. Lighthill, Beyer professor of applied mathematics, University of Manchester; Prof. D. M. Newitt, Courtauld professor of chemical engineering, Imperial College of Science and Technology; Prof. G. Pontecorvo, professor of genetics, University of Glasgow; Prof. R. J. Pumphrey, Derby professor of zoology, University of Liverpool; Prof. H. W. B. Skinner, Lyon Jones professor of physics, University of Liverpool; Prof. Wilson Smith, professor of bacteriology, University College Hospital Medical School, University of London; Prof. J. Z. Young, professor of anatomy, University College, London.

Royal Society and Nuffield Foundation Commonwealth Bursaries

Awards under the Royal Society and Nuffield Foundation Commonwealth Bursaries scheme have been made as follows: Dr. I. R. C. Bick, senior lecturer in organic chemistry, University of Tasmania, to assist him to visit Cambridge, during June 1959–March 1960, in order to study the latest developments and research techniques in natural products organic chemistry; Mr. E. H. Davis, senior lecturer in civil engineering, University of Sydney, to enable him to study the stress – strain properties of the soil matrix, and the application of the theory of plasticity to soil, at Watford and the Imperial

College of Science and Technology, London, during February–December 1959; Dr. P. R. Davis, lecturer in anatomy, Royal Free Hospital School of Medicine, London, to enable him to extend his studies of African human skeletal material at Khartoum, Ibadan and Makerere, to study fossil primate material at Nairobi and to visit fossiliferous sites, for six months from February 1959; Prof. C. M. Donald, professor of agriculture in the Waite Agricultural Research Institute, University of Adelaide, to enable him to study recent advances and techniques in agronomic research at Hurley and elsewhere in the United Kingdom, for three months from April 1959; Prof. P. C. Dutta, professor of organic chemistry, Indian Association for the Cultivation of Science, Jadavpur, to enable him to gain experience in the field of alicyclic compounds related to terpenoids, at the Imperial College of Science and Technology, London, and Oxford, for about ten months from May 1959; Dr. A. Iggo, lecturer in physiology, University of Edinburgh, to enable him to gain experience of techniques for the analysis of spinal cord activity and to apply these in further investigation of the nature of rhythmic nervous activity in mammals, at Canberra, for about five months from July 1959; Dr. L. N. D. Lucas, senior lecturer in physics, University of Western Australia, to enable him to gain experience in the use of electron microscopy to study the microstructure of solids, at several centres in the United Kingdom, for about ten months from March 1959; Mr. I. L. Mason, of the Agricultural Research Council Unit of Animal Genetics, Edinburgh, to enable him to visit Australia and New Zealand for about ten months in 1959, in order to study animal breeding research there, particularly on beef cattle under tropical and sub-tropical conditions; Dr. Jean M. Tyler, Imperial Chemical Industries Research Fellow, Department of Chemistry, University of Edinburgh, to enable her to carry out structural investigations on West Indian natural products at Kingston, Jamaica, for a year from April 1959; Dr. J. M. Vincent, associate professor of agricultural microbiology, University of Sydney, to enable him to continue his studies of the root-nodule bacteria at Rothamsted, for about eight months during 1959.

The New Humanism of Science

Is science a triumphal march or a stumbling shuffle from one intellectual expedient to another? Mr. Frank Greenaway thinks the latter, and in the *Universities Quarterly* (12, 130, 228, and 13, 24; 1957–8) compares the modern scientist to a caterpillar tractor, perpetually pulling up his support behind him as he goes. The pseudo-literature of experimental reports exfoliating every week hides the real understanding of science, precludes 'eaves dropping' by other educated men and drives fissures into our intellectual society. "It is a curious thing," he writes, "that while most intellectual people are well aware of a sense of tradition in the things they respect as the basis of their culture, they have very little idea of any tradition in science." As he points out, Copernicus, Agricola and Vesalius published their principal works before Shakespeare was born; most music is younger than modern chemistry, and most plays than the discovery of the electron. Going beyond the "New Humanism" of the late George Sarton, Mr. Greenaway remarks that the scientist has been served by fewer and less able biographers than any of his class of creative thinker, and suggests that there is a great field open to writers to rescue the life of science by rescuing the lives of the scientists and so enable their successors to see science apprehended as a unity.

Mr. Greenaway's closely argued, cogent plea for the restoration of the traditional element in modern conceptual thinking about science presents it as "one of the keys to the new understanding of science which we need". He looks across the fissure to the arts, where the direct relation between the professional creator and amateur assessor continues. He looks ahead to the time when a good scientist will take the trouble to ensure that his paper will survive. Mr. Greenaway mentions Acton; yet might also have included A. L. Rowse, who, though he wrote "I am not merely uninterested, I am positively anti-scientist. I regard it as essentially a specialist activity for people to take to after they have been educated", and could yet say "still, if I had been told something of the fascinating story of mathematics and the men of genius who built up their body of knowledge it would have been quite different".

Bernice P. Bishop Museum, Honolulu

The annual report of the Bernice P. Bishop Museum for 1957, entitled "Concept of the Pacific" (pp. iv+31. Honolulu, Hawaii: Bernice P. Bishop Museum, 1958), follows, as usual, a rather unorthodox pattern. The Pacific has for long been one of the world's major regions of investigation, and it is rightly emphasized that this immense area of ocean, islands and continental margins has a great degree of unity. The report indicates the manner in which the Museum has taken part in research work in the Pacific area, exhibited displays on present and past activities in the region, and makes the interpretation of a knowledge of the Pacific to the public at large its major objective. The chief effort of the year was the installation of exhibits in the Hall of Pacific Life, which is intended to provide a background of the physical geography and natural history of the area.

Engineering Materials and Design

The present era with its ever-increasing rate of advancement in all fields of technology has brought forth many demands for new and better materials and also a great yield of new materials. These two factors are inter-related, but lack of an up-to-date information service has been a serious drawback for the majority of engineering designers. The object of *Engineering Materials and Design* (1, No. 1; October 1958. Pp. 58. Published monthly. Annual subscription 35*s.*; 5.25 dollars. Single copies 2*s.* 6*d.* London: Heywood and Co., Ltd., 1958) is to bring to engineering designers information of new design and material developments in all branches of engineering. This information will be presented in articles, reports and data sheets prepared by authors with first-hand experience. The first issue contains a selection of articles on widely differing topics ranging from uses of titanium and new developments in polyethylene to the selection of fractional horsepower motors and the organization of a modern drawing office. The data sheets included in this number are concerned with molybdenum, polystyrene and new sandwich-material applications. The layout is clear and in contemporary style. If the present standard is maintained, the periodical will succeed in its object.

Aeroelasticity Surveyed

THE second Lanchester Memorial Lecture, given on November 20 before the Royal Aeronautical Society by Prof. A. R. Collar, of the University of Bristol, was entitled "Aeroelasticity—Retrospect and Prospect". Prof. Collar began with a historical survey, mentioning the investigation of flutter made by Lanchester in 1916 before turning to the pioneer work of Duncan and Frazer, who published a paper on "The Flutter of Aeroplane Wings" (1928), which is still a standard reference. Problems of flutter, wing and tailplane divergence, fuselage bending and control reversal multiplied with the advent of the monoplane and during the intense development period of the Second World War. Prof. Collar reiterated his earlier suggestion that by treating the dynamics of a deformable aircraft, all aeroelastic problems could be solved, and added the ray of hope that electronic computers may soon be able to turn a theoretical possibility into a practical reality. He thought that the important recent developments of flight simulators, ground resonance tests and elastic wind-tunnel models, together with greatly increased industrial interest in aeroelastic problems, would ensure fewer accidents in the future. Prof. Collar stressed the need for a better understanding of the effects of damping, which should suppress but often only aggravates flutter. He also wanted to see better methods for estimating air forces. The future problems of very high-speed flight will present kinetic heating effects liable to distort the slender wing sections to a degree not previously experienced. A powerful analytical treatment will be needed.

Tokyo Observatory Polar Tube

THE determination of the position of the celestial pole is of interest in connexion with the construction of star catalogues, the measurement of the precise values of the astronomical constants of precession, nutation and aberration and the movement of the pole due to geophysical disturbances. The meridian circle has been employed in the past for this kind of work, but the installation of a fixed telescope pointing to the pole has certain advantages, including the use of the same star-field at each observation and the simplified structure leading to less complicated nstrumental errors. This idea was first put into practice at the Poulkovo Observatory near Leningrad, and a similar telescope, which they named a polar tube, has been constructed at the Tokyo Observatory by N. Sekiguchi and J. Matsumoto *Annals Tokyo Astro. Obs.*, 5, 131; 1957; *Pub. Astro. Soc. Japan*, 9, 116; 1957). The objective of diameter 20 cm. has a focal length of 269 cm. The photographic plate is rotated about the optical axis at the sidereal rate so that stars are photographed as point images. An almost plane-parallel glass plate n front of the objective has at its centre a small luminized reflecting surface, inclined to the plate at uch an angle as to cause light from the optical axis f the polar tube to be reflected vertically downwards nto a mercury basin. A pencil of light is led into the ube. Some is reflected from the glass plate to form n image on the photographic plate. Some is reflected rom the reflector, mercury and reflector again and orms a second image, shifted slightly from the first mage. Changes of position of the two images give nformation on the motion of the plate relative to he objective. The plate is exposed twice, for about ve minutes on each occasion, at an interval of five r six hours. Ten tenth-magnitude stars are used. The common point of the two star-fields photographed is, after certain corrections have been applied, the position of the celestial pole at that date. Preliminary observations suggest a probable error of 0·3 second of arc for one observation.

Transformation Characteristics of Direct-hardening Nickel Alloy Steels

A MONOGRAPH entitled "Transformation Characteristics of Direct Hardening Nickel Alloy Steels", recently issued by the Mond Nickel Co., Ltd. (pp. 91. London, 1958), is a revised and enlarged edition of the "Atlas of Isothermal Transformation Diagrams of Nickel Steels" previously published. The information contained in the sixty pages of text and twenty-five pages of diagrams is excellently presented, and the bibliography of eighty-six references adds further to the utility of this little book. In addition to the isothermal diagrams and data on end-quench hardenability previously reproduced, the revised publication incorporates supplementary information in the form of continuous-cooling transformation diagrams. This is of value, since the difficulty of applying isothermal data to practical heat-treatments lies in the fact that it is not possible to assess reliably from isothermal diagrams the extent and type of transformations which may occur during continuous cooling. The diagrams shown are for sections from 1 in. to 6 in. in diameter, quenched in oil. Both smaller and much larger sections are of course used, and other cooling media, but this information will probably prove the most generally useful to the engineer in the treatment and application of steels containing nickel.

Charles Leopold Meyer Award for 1958

THE Société de Chimie Biologique has awarded the Charles Leopold Meyer Award for 1958 jointly to Dr. François Gros of the Institut Pasteur, Paris, and to Prof. Jean Turchini; of the faculty of medicine, Montpellier. This annual award of 500,000 francs is made for research on the nucleic acids. Dr. Gros has worked on the mechanism of action of various antibiotics on bacteria; in particular he has studied how antibiotics modify the degradation and reconstitution of the nucleic acids in the cell. Prof. Turchini has conducted a number of investigations over a period of years, partly in collaboration with Prof. P. Castel and Dr. K. van Kien, using specific staining techniques to localize certain nucleic acids within the cell and to follow their evolution under the microscope.

Paul Instrument Fund Awards

AWARDS of grants by the Paul Instrument Fund Committee have been made as follows: £3,835 to Prof. A. L. Cullen, professor of electrical engineering in the University of Sheffield, for the construction of a detector in which radiation pressure is used to convert a microwave signal to an audio or intermediate frequency; £545 to Dr. R. Feinberg, of the Department of Electrical Engineering, Manchester College of Science and Technology, for the construction of an instrument for measuring the intensity of soft X-radiation generated in experimental high-voltage valves; and £1,000 to Mr. R. M. Sillitto, lecturer in natural philosophy, University of Edinburgh, for the development of a thirty-channel pulse-height analyser, using transistors in place of thermionic valves.

The Paul Instrument Fund Committee, composed of representatives of the Royal Society, the Physical

Society, the Institute of Physics and the Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Simon Memorial Prize

In memory of the late Sir Francis Simon, the Low Temperature Group of the Physical Society has decided to institute a prize to be known as the Simon Memorial Prize, to be awarded for distinguished work in experimental or theoretical low-temperature physics. An appeal for financial support has been made to several industrial firms, and their generous support has already ensured the success of the scheme. However, it is believed that many other organizations and individuals will wish to make small contributions so that the memorial is truly representative of the many who have known and benefited from the life and work of the founder of the Group. The fund will therefore remain open until the annual general meeting of the Group on January 15, and contributions should be sent to the Chairman or Hon. Secretary before that date, addressed to the Low Temperature Group, Physical Society, 1 Lowther Gardens, Prince Consort Road, South Kensington, London, S.W.7.

University News: Glasgow

The U.S. National Institutes of Health have provided a grant of 45,000 dollars for one year, renewable at the rate of 27,000 dollars for each of four successive years, for the expansion of research on human genetics in the Department of Genetics. This has made possible the planning of a concerted attack on the problem of whether genetic analysis in man, and slow-breeding animals and plants, can be based on mitotic segregation in somatic cells. Investigation of this problem, under Prof. G. Pontecorvo, requires initially the combination of research workers with a variety of skills—for example, protein chemists, immunologists, virologists. For this reason, the grant provides not only for equipment, but also for adequate visiting fellowships, which will permit senior workers to join the team for suitable periods. With the installation of the English Electric DEUCE computer at the beginning of this session, the Computing Laboratory has now been established under the direction of Dr. D. C. Gilles; and additional staff, including D. C. Williams as lecturer, has been appointed. Arrangements are being made for a formal opening of the Department in the New Year. The new engineering building at the eastern extremity of the University site is now occupied. A. F. Munro has been appointed senior lecturer in veterinary physiology, and C. G. Elliot, Matthew Holmes and Ian S. Hughes have been appointed to lectureships in agricultural botany, physiology and natural philosophy, respectively. For the present session, 372 new students (284 men and 88 women) have been admitted to the science departments, compared with 351 in 1957. The total of matriculated students in the University as a whole now stands at 6,330.

Qualifications in Mathematics

The Council of the Mathematical Association has set up a sub-committee to consider and report upon the proposal that the Association should establish an examination machinery in mathematics. The underlying principle is that there are many teachers who would wish to improve their academic qualifications but who have neither the time nor the facility to read for an external degree. It is thought that a diploma of efficiency in either or both pure and applied mathematics to the standard of the old ordinary degree might be of value to these men and women and, at the same time, a reward for further study.

Announcements

Prof. A. Salam, professor of applied mathematics in the Imperial College of Science and Technology, London, has been awarded the Hopkins Prize of the Cambridge Philosophical Society for his contribution to the theory of non-conservation of parity in physics. The Prize has been awarded every three years since 1867 for work in mathematical–physical or related fields. The present award relates to the period 1955–57, and is of the value of £80.

The Transactions of the fourth International Congress on Biochemistry, held in Vienna during September 1958, representing all the symposia, colloquia and discussions, will be published in fourteen volumes by the Pergamon Press. These will appear early in 1959.

The British Institution of Radio Engineers announces the formation of a Medical Electronics Group. This is in accordance with the policy of the Council to establish specialist groups to foster the general dissemination of information in the specialized fields of radio and electronic engineering. The chairman of the Group Committee is Mr. W. J. Perkins. There will be five meetings of the Group during the current session. The inaugural meeting will be on January 23, when Prof. A. V. Hill, emeritus professor of physiology in University College, London, will give an address.

The Department of Extra-Mural Studies of the University of London and the Association of Agriculture are holding a course of ten weekly lectures on "Britain's Food Supplies". The lectures will be given weekly at 6.30 p.m., starting on January 14 at the British Institute of Recorded Sound, 38 Russel Square, London, W.C.1.

An International Colloquium on Communication and Language is being organized by the Faculty of Medicine of the University of Paris, with the collaboration of the professor of otorhinolaryngology the Société Française de Phoniatrie, the Laboratory of Physiological Acoustics and the professor o neuro-physiology in the Collège de France. It will be held at the Faculty of Medicine, 45 rue des Saints Pères, Paris 6e, during January 22–25, 1959. Communication and language will be discussed from the point of view of information theory, and the programme will deal with the following aspects of the subject: mathematical and philosophical, physical physiological, pathological, psychological, statistical Further information can be obtained from Dr. B Vallancien, 16 rue Spontini, Paris 16e.

Erratum. In the communication entitled "Alar Polymorphism in the Gerroidea (Hemiptera Heteroptera)", by Dr. R. O. Brinkhurst, in *Nature* o November 22, p. 1461, par. 3, line 11, for "grow" read "row".

SPACE MEDICINE

THE first symposium on space medicine to be held in Great Britain was held at B.M.A. House, London, on October 16 and 17. The symposium was organized by the British Interplanetary Society, and coincided with the twenty-fifth anniversary of its foundation. The symposium was arranged to discuss the reactions of man to the conditions that will be encountered in space and on other planets, and of the equipment that will be required for survival in these hostile environments. Those taking part were research workers in physiology, psychology and human engineering; and the term 'space medicine' embraces the application of these sciences to extra-terrestrial environments.

It is certain that man will travel into space within a few years. His first venture will probably be in orbit, close to the Earth, and lasting a few hours. His second venture will be to the Moon, and his third to one of the planets. Voyages beyond our own solar system are difficult to comprehend, but should not be dismissed too lightly.

The reason for man travelling into space is a controversial subject. Some contend that he merely adds to the complexity of the space vehicle; others that he will earn his keep by taking decisions, particularly in the event of an unforseen emergency. The fact remains, however, that he will go, and that he will be faced with many of the problems discussed at the symposium.

The chairman of the British Interplanetary Society, Dr. L. R. Shepherd, opened the conference with a brief review of the major problems facing man in space, seen from the point of view of a physicist. Over the course of two days, fourteen papers were delivered, and covered fairly well the salient problems of space medicine.

The major physiological difference between travel in a space vehicle and some Earth-bound vehicle such as a submarine is the absence of the gravitational force. Dr. M. P. Lansberg, of the National Aeromedical Centre in Holland, discussed in his paper some consequences of weightlessness. In the absence of gravitational clues to position, some disorientation may occur, and motor activities will have to be re-learned. Complete immersion in water produces some of the characteristics of weightlessness, and a true state of free fall can be produced for periods of about half a minute by parabolic flight in an aircraft. It would be unwise to extrapolate from such flights to the condition of prolonged weightlessness because of the stresses which precede the parabolic flight and because of its short duration. Von Braun has proposed that the space vehicle should rotate, providing artificial weight for the occupants at its periphery. There are serious disadvantages to this system. Changes in weight would be experienced after moving closer to the centre of rotation and also when walking in the direction of rotation, or in the opposite direction, at a constant distance from the centre of rotation. Perhaps more serious, movement of the head would cause tilting and turning sensations, with their appropriate reactions, in the wrong planes. This is due to rotation of the semi-circular canals of the ear while under the influence of a centrifugal rather than a gravitational force.

Some disorientation would seem to be inevitable. Sqn. Ldr. T. C. D. Whiteside, of the R.A.F. Institute of Aviation Medicine at Farnborough, emphasized the importance of the oculogravic and oculogyric reflexes, and issued a warning on the possible seriousness of motion sickness.

Flt. Lt. J. C. Guignard, of the R.A.F. Institute of Aviation Medicine, considered that accelerations at multiples of g, lasting for several minutes, to which the astronaut will be exposed during a rocket take-off, are probably acceptable for a man aligned in the correct position. He concentrated on the physiological effects of transient mechanical forces. Noise and vibration levels are high in large rocket vehicles under power. and, during re-entry at orbital velocities, buffeting of a space vehicle would be poorly damped at the fringe of the atmosphere, and might induce vibrations and oscillatory flight patterns of sufficient intensity to prohibit the crew from controlling the descent. In space, there will be no damping, and any vibration must be absorbed by the vehicle and its occupants. Structure-borne oscillations at frequencies below 100 c./s. are a potential cause of discomfort, fatigue and impaired performance; and low-frequency shaking, below 10 c./s. is a serious nuisance and is difficult to isolate. Flt. Lt. Guignard doubted whether man would float about in an orbital space-suit constructing a satellite from its component parts. If he did, the suit or capsule would have to be a massive affair incorporating gyroscopic stabilization to prevent undamped spin or tumble (which might be fatal), and whole-body harness and anti-shock packaging to save him from impact injuries in a collision.

Dr. H. Bjurstedt, of the Laboratory of Aviation and Naval Medicine at Stockholm, described the results of subjecting anæsthetized dogs to prolonged g forces in the head-to-tail direction. He found hypoxæmia in spite of the fact that the animals were hyperventilating and breathing 100 per cent oxygen, and attributed this to disturbances of ventilation and perfusion in the lungs. It was not clear why there was present, also, a marked alkalosis.

Dr. C. J. Clemedson, of the Research Institute for National Defence in Stockholm, considered the relationship between his studies on blast injury in animals and the problem of explosive decompression in a space vehicle.

Commander G. W. Hoover led a team from the U.S. Office of Naval Research. He delivered a paper on the man–machine system in space vehicles. This consisted, in essence, of proposals for an integrated approach by all concerned to the problem of finding out under what conditions a man works most happily and efficiently in a closed vehicle. These conditions would then be specified for the space vehicle.

The American delegation was emphatic in demanding a cabin environment which did not subject the crew to any unnecessary physiological or psychological strain. Dr. G. Pugh, of the Medical Research Council, was also in favour of a comfortable environment, but pointed out that, as in the case of explorers of the past, the demand for reduction in weight and complexity might necessitate exploitation of man's capacity to adapt himself to a wide range of environmental stresses. He discussed the possibility of reducing metabolic rate and of breathing oxygen at low partial pressures to save weight in food and oxygen. Dr. Pugh also made the important point that while lack of preparation had been the undoing of many previous explorations, the ultimate test of performance is in the real situation.

Flt. Lt. J. Billingham, of the R.A.F. Institute of Aviation Medicine, examined the problems of heat exchange between man and the sealed cabin, and proposed a specification for environmental conditions during interplanetary flight. He also presented a paper on heat exchange between man, his pressure suit and the environment on the surface of the Moon.

Dr. K. F. Jackson, of the R.A.F. Institute of Aviation Medicine, read a paper on the impairment of human performance in control. He presented the results of an investigation into the factors affecting performance of the crews of long-range reconnaissance aircraft, with particular reference to fatigue. He also demonstrated a portable version of his multiple tracking test apparatus, which provides measurements of about ten different aspects of performance.

Mr. C. Cunningham, from the Air Ministry, described the effects of sensory impoverishment, confinement and deprivation of sleep. If these are allowed to continue unchecked for a number of days, the result is changes in the personality and the intellect, often to a degree where logical thought and action become impossible. His evidence was obtained from experimental work, particularly that of Hebb, and from the experiences of former prisoners. There is no doubt that these factors will be of paramount importance in space travel, especially in the case of journeys lasting for years.

Dr. A. S. Parkes and Dr. Audrey V. Smith, of the National Institute for Medical Research, directed attention in their paper on the transport in space of life in the dried or frozen state to the considerable economy of carrying some of the crew of a space vehicle in a state of suspended animation. They considered, however, that the possibility of freezing man was remote. On the other hand, there should be less difficulty in landing spores and seeds on another planet.

Mr. S. W. F. Hanson, of the Ministry of Agriculture, discussed the very practical problems of feeding during travel in space, and the difficulties in the maintenance of a biological cycle, including plants, for journeys of long duration.

The final speaker was Dr. A. E. Slater, of the British Interplanetary Society, who must take credit for the organization of the symposium. He discussed the hazards to man of the radiation belt revealed by the *Explorer* satellites. A region of intense radiation exists between latitudes 30° N. and 30° S. of the magnetic equator. Singer attributed this belt to protons captured in the Earth's magnetic field, and his theory has received considerable support from the information received from the American rocket *Pioneer*, which showed the radiation to be maximal at an altitude of 5,700 miles. Dr. Slater concluded on an optimistic note, describing a suggestion by Singer that the radiation belt could be mopped up in one year by a satellite some ten metres in diameter travelling in an appropriate orbit. J. BILLINGHAM

CHEMICAL PATHOLOGY OF THE NERVOUS SYSTEM

THE subject of the third International Neurochemical Symposium, which was held in the University of Strasbourg during August 25–29, was "The Chemical Pathology of the Nervous System". Several facets of this ramifying topic were discussed by experts from a number of countries, and as those attending the Symposium were restricted to a comparatively small number (130) there were often vigorous and satisfying discussions. As in previous similar symposia, the main subjects were subdivided so that there could be reviews followed by short individual papers on related topics.

A whole day was devoted to metabolic disorders, and the inborn errors of metabolism received detailed attention from Dr. G. A. Rose (London) and Dr. G. A. Jervis (New York). Dr. Rose described a new form of mental defect characterized by the excretion of arginosuccinic acid, and suggested that mental defect may, in fact, include a large group of metabolic diseases of which 'arginosuccinuria' is one, the biochemical lesion in this condition being the inability to split arginosuccinic acid into arginine and fumaric acid.

In this section, too, there were interesting papers on phenylketonuria and Hartnup's disease (Dr. R. Rodnight, London), and the subject of the cerebral lipidoses was also discussed. In connexion with cerebral lipidoses, Dr. M. Lees (Boston) pointed out that analytical methods suitable for normal brain tissue may not necessarily be applicable to pathological material. It was obvious, too, that much more precise information on the chemical nature of brain gangliosides and sulphatides is desirable if rapid progress is to be made in this field. Dr. H. M. Sinclair (Oxford), reviewing the subject of metabolic disorders of nutritional origin, emphasized the wide variety of dietary substances necessary for the adequate maintenance of a 'normal' nervous system.

Prof. J. M. Cumings (London), in a comprehensive review of the chemical pathology of copper, paid particular attention to the copper protein present in brain tissue and its possible significance. The chemical nature of cerebrocuprein in normal brain and that obtained from the brain of individuals suffering from Wilson's disease (hepatolenticular degeneration) was then discussed by Dr. H. Porter (Boston), who has found a significant difference in the chemical properties and electrophoretic mobilities of the two proteins. Members of the Symposium found this an exciting new observation.

The fact that a considerable number of biochemical investigations have been carried out on demyelination processes was reflected in a number of interesting papers on this topic. A review of demyelination in general was given by Dr. R. D. Adams (Boston), and a masterly and concise account of Wallerian degeneration by Prof. R. Rossiter (London, Canada) vividly demonstrated to the audience how precise chemical studies can be used to map a pathological process. Dr. E. Robins's (St. Louis) studies on the biochemistry of chromatolysis in individual anterior horn cells after axonal section illustrated the significance of analysis of individual cells in a heterogeneous system. The importance of developing new techniques in investigations of this kind cannot be overemphasized. Dr. A. Lajtha (New York) presented isotopic evidence suggesting that protein synthesis occurs continuously in the nerve cell body and that there is a flow of protein down the axon. Nissl granules, which are apparently essential for protein synthesis, are absent from the axon.

In a survey based largely on his own experimental observations, Dr. K. A. C. Elliot (Montreal) discussed the problem of swelling and shrinkage in nervous tissue. This was supplemented by Prof. E. W. Dempsey's (St. Louis) account of electron microscopic studies on nervous tissue. He informed the audience that there is an interstitial space in brain tissue which is not negligible. The uptake of fluid into oligodendroglial cells is one way in which swelling can take place.

Under the broad heading of "The Chemistry of Convulsive States and Allied Disorders" there were a number of reports on the significance of γ-aminobutyric acid, glutamic acid and glutamine in brain tissue. For some years the relatively high concentration of these three substances has aroused interest, and further investigations have now been stimulated by the finding that 'Factor I' activity is intrinsically associated with γ-aminobutyric acid. Glutamic acid and γ-aminobutyric acid appear to have opposite effects in brain tissue, and Dr. E. Roberts (Duarte) remarked that the relative levels of glutamic acid and γ-aminobutyric acid may be determined by the intracellular *p*H.

Prof. H. McIlwain (London) gave an interesting discourse on some of his more recent studies on the electrical stimulation of isolated brain tissue. He has found that the subcortical white matter gives a much better response to localized stimulation on the surface than does grey matter, suggesting that the response is transmitted through the white matter. In further experiments Prof. McIlwain has also succeeded, for the first time, in obtaining resting potentials from isolated white matter.

The last two days of the meeting were devoted to the biochemistry of mental disease, in which a considerable amount of research is now being carried out. Dr. A. Pope (Waverley) impressed everyone with his account of the distribution of certain enzymes in various cellular layers of the isocortex of normal and psychotic subjects. Biopsy material from leucotomy operations was used, and the studies may well be unique in that, with the increasing use of tranquillizing drugs, the number of leucotomy operations is being rapidly reduced, cutting off the source of material. In the event, there did not appear to be any specific difference between the enzyme distribution in normal and psychotic individuals so far as the isocortex is concerned.

Dr. M. Reiss (New York) reviewed the importance of hormone studies in mental disease and the value of considering the human organism as a whole. Carbohydrate metabolism in mental disease was reviewed by Dr. H. E. Himwich (Galesburg) with special reference to blood-sugar tolerance curves. Dr. Himwich also discussed whether or not the psychotic individual responds to biochemical stress in the same way that the normal does. The problem of glucose utilization by schizophrenics was discussed by Dr. M. D. Altschule (Waverley), who suggested a direct relationship between the mental state of the individual and the capacity to metabolize carbohydrate. Several members of the audience disagreed with this observation.

In a survey of the relationship between protein metabolism and mental disease, Dr. D. Richter (Cardiff) emphasized the great lack of basic knowledge on the nature of the proteins of the central nervous system. No protein had been well characterized to date, and until this was done progress would be slow, although some advances had been made by electrophoretic methods. It was obvious that the infinite possible variations in the structure of proteins could well be of significance in the nervous system, and different proteins appeared to exist in different parts of the brain. Dr. Richter also pointed out that in many mental disorders there was evidence of developmental failure which might be related to deficiencies in protein metabolism. For example, the mongol brain had an 'unfinished' appearance, while epileptic seizures might be considered to represent a persistence of embryonic convulsions. Furthermore, the fact that twenty-five per cent of all schizophrenic symptoms commenced in the period from 15 to 25 years of age, suggests a relationship between the disease and maturation changes.

If knowledge on brain protein metabolism is scanty, the same cannot be said for the metabolism of amines. A vast amount of research is now under way on the metabolism of amines and their pharmacological effects. Thus it is becoming hard to keep abreast of the large number of published studies on 5-hydroxytryptamine. In his review on the metabolism of amines in mental disease, Dr. E. A. Zeller (Chicago) stated that chromatograms of the amines present in the urines of normal subjects showed that more than thirty different amines could be detected. The urines of schizophrenics gave a different pattern; but very few of the amines had been identified. Prof. H. Waelsch (New York) gave an account of some new results from his laboratory which showed that *in vitro* certain liver protein fractions can take up amines labelled with carbon-14 in covalent linkage, the amine displacing ammonia, probably from the ε-amino group of lysine. The possibility that amines might form modified proteins in this way provoked a long discussion. Some fresh experiments on epinephrine metabolism were then presented by Dr. J. Axelrod (Bethesda), who stated that the formation of adrenochrome is a most unlikely step in epinephrine catabolism. In support of this he has now shown that the major metabolite of epinephrine labelled with tritium is a methylated compound (metanephrine). An enzyme capable of methylating epinephrine is apparently widely distributed. Interesting papers by Dr. T. L. Sourkes (Montreal) and Dr. H. Weil-Malherbe (Washington), on the urinary excretion of catecholamines by psychotic individuals, underlined the current interest in aberrations of amine metabolism.

In a closing speech Dr. S. S. Kety (Bethesda) analysed theories of the biochemical etiology of mental disease. In a satisfying and illuminating way he reviewed the work of those investigators who have concluded that this or that toxic substance, or group of substances, is characteristic of mental disorder, and his conclusion was that no one has convincingly demonstrated a biochemical lesion characteristic of the psychoses. The recent studies on ceruloplasmin, thought to be present in increased amounts in schizophrenic plasma, have proved to be incorrect, while the reports on taraxein, a toxic factor from schizophrenic blood, have proved equivocal. Dr. Kety affirmed that it was most difficult to plan experiments to compare psychotics with normal controls. To obtain proper controls was a considerable feat in itself, and most research had been carried out on patients in institutions who had, among other things, been on an unusual diet. This latter consideration often accounted for reports of the atypical urinary constituents of mental patients. The subconscious desire on the part of the investigator to eliminate conflicting data had also to be overcome. There was considerable discussion after Dr. Kety's paper on the problems inherent in undertaking biochemical studies in mental disease, and one or two speakers put in a plea for investigators to publish negative findings, if only to eliminate duplication of effort.

Altogether the Strasbourg conference was a stimulating experience and thanks are due to the organizing committee for the first-class presentation. All members of the Symposium are indebted also to Prof. Mandel and the Comité de Patronage for the hospitality shown in Strasbourg, and no one will easily forget the many social events organized for the delight of members, especially the outing to Obernai.

G. B. Ansell

HUMAN AND ANIMAL MYCOLOGY

THE International Society for Human and Animal Mycology met in Lisbon during September 5–10. The meeting, the first since the Society was founded in Paris in 1954, was held by permission of the President and General Secretary of the Sixth International Congresses on Tropical Medicine and Malaria. It was attended by more than sixty members of the Society, and twenty-one countries, including the U.S.S.R., Japan, the United States, Brazil, South Africa and Australia, were represented.

Three of the sessions on tropical medicine were devoted to mycotic infections, and these covered the clinical and epidemiological aspects of mycoses, the ecology and saprophytic occurrence of pathogenic fungi and the biochemistry and physiology of pathogenic fungi. In addition, the Society held two business meetings and three paper-reading sessions. Altogether there were more than forty communications, and ample time was allowed for discussion.

In a brief report of the proceedings it is difficult to select, from the many papers presented, those most worthy of note. However, no account would be complete without reference to the contributions on the ecology of pathogenic fungi. Dr. C. W. Emmons (United States) pointed out that, for many of the mycoses, we know that saprophytic growths provide the inocula from which man and animals are infected, and that all epidemiological evidence suggests the probability of saprophytic sources of inocula for a number of other mycoses. He suggested that attempts to isolate the fungi from soil of areas where the specific mycoses are endemic, and a more careful comparison of certain rare pathogens with fungi already described in the literature of general mycology may well increase or complete the list of pathogens with known saprophytic sources. Dr. Emmons said that most of the pathogens of man have a wide geographical distribution and their local distribution is dependent upon ecological factors only partially recognized.

The results of a four-year study of *Coccidioides immitis* in the soil of the South-West Joaquin Valley of California were given by Dr. Egeberg (United States). He discussed the ecological and epidemiological significance of the recovery-rate of the fungus being highest in surface soil three to four weeks after the end of the rainy season, most consistent from the walls of animal burrows, and lowest from the surface towards the end of the dry season when the incidence of the disease is at its highest.

Dr. P. Abbot (Britain), in his consideration of mycetoma, noted that for this disease the incidence is apparently correlated with climatic conditions rather than with specific soil types or other factors. The recovery of the dermatophytes *Microsporum canis*, *M. gypseum* and the non-pathogenic keratinophilic fungi *Trichophyton terrestre*, which is a new species, and *Keratinomyces ajelloi* from the soil of Australia and New Guinea was discussed by Dr. E. B. Durie (Australia), who also reviewed previous work on the ecology of dermatophytes. In his consideration of the mouth as a reservoir of pathogenic fungi, Dr. G. C. Ainsworth (Britain) pointed out that of the many and diverse fungi recorded from the mouth, most are 'contaminants' and only a small number may be considered as 'inhabitants'. Some of the 'inhabitants' appear to provide a reservoir of infection for such endogenous diseases as candidiasis and actinomycosis. A single isolation of *Cryptococcus neoformans* from a healthy horse, during his investigations into the intestinal yeast flora of man and domestic animals, was reported by Dr. N. Van Uden (Portugal). This pathogenic yeast has been shown in the United States to be frequently associated with pigeon droppings, and Dr. K. Ishida (Japan) reported similar findings in Tokyo.

Histoplasmosis was the subject of a number of contributions. The first occurrence of this disease in Japan was reported by Dr. H. Yamato, and a paper on the distribution of histoplasmosis in South Africa was given by Dr. H. I. Lurie. Dr. E. Drouhet (France) and Dr. J. Schwarz (United States) both reported that in culture there is no apparent difference between *Histoplasma duboisii*, first described by Vanbreuseghem in 1952, and *H. capsulatum*. However, the geographical distribution and the clinical and pathological aspects of African histoplasmosis caused by *H. duboisii* differ considerably from the classic form of the disease caused by *H. capsulatum*, and it was generally agreed that for the present it is useful to consider them separately.

In an interesting communication Dr. A. C. Batista (Brazil) stated that from the results of investigations carried out in Brazil it is clear that fungi such as *Candida* and *Torulopsis* may be a primary cause of cholecystitis. Dr. C. S. da Silva Lacaz (Brazil) gave an excellent account of the clinical and epidemiological aspects of the serious mycoses in South America and also showed a most interesting film which he had made on South American blastomycosis.

The importance of therapy was not overlooked. Dr. M. Muftic (Iraq) reported on trials of mycostatin (nystatin) derivatives used intravenously and intramuscularly for the treatment of coccidioidomycosis, and Dr. J. C. Gentles (Britain) gave an account of experimental work which demonstrated the efficacy of oral treatment with the antibiotic griseofulvin for dermatophyte infections.

The use of serological tests for identification and classification of fungi were considered by Dr. H. Seeliger (Germany) and Dr. T. Tsuchiya (Japan).

The social side of the Congresses in tropical medicine and malaria, in which Society members took part, was well organized, and it would be difficult to speak too highly of the hospitality of our Portuguese hosts. The impressive opening ceremony was held in the National Assembly (Palace of São Bento) under the presidency of His Excellency the President of the Republic of Portugal. Evening visits were arranged to places of interest in Lisbon, such as the *estufa fria* (cool greenhouse) in the Parque Eduardo VII and to palaces and gardens in the neighbouring towns of Sintra and Queluz. On the first Sunday there was an excursion to the University of Coimbra.

During the two business meeetings of the Society it was announced that there are now more than two hundred members, and that it would shortly be possible to begin publication of a journal devoted to human and animal mycology. It was agreed that membership of the Society should be open to all interested in medical and veterinary mycology. The date for the next meeting is to be decided by the executive committee: *President*, J. E. Mackinnon (Uruguay); *Vice-Presidents*, G. C. Ainsworth (Britain); C. W. Emmons (U.S.A.); P. Negroni (Argentine); G. Segretain (France); *General Secretary*, R. Vanbreuseghem (Institut de Médecine Tropicale, 155 rue Nationale, Antwerp). J. C. GENTLES

STUDENT APPRENTICESHIP IN ELECTRICAL ENGINEERING

STUDENT apprenticeship is the subject of a report* published recently by the Institution of Electrical Engineers. The report is the work of a joint committee, under the chairmanship of Sir Willis Jackson, appointed by the Council of the Institution in consultation with the Council of the British Electrical and Allied Manufacturers Association, the Radio Industry Council and other interested bodies.

It is stated in the foreword that the report aims to do two things: first, to explain to teachers, senior pupils and parents the scope of the educational requirements and the training envisaged in student apprenticeship for electrical engineering; and secondly, to give guidance to those responsible for the education and training of student apprentices as to the structure and content of academic courses and practical training.

Graduate apprenticeship and student apprenticeship are the two main avenues leading to professional qualification in electrical engineering in Britain. A university graduate, on completion of his three- or four-year full-time course of study, will normally undertake a two-year apprenticeship with a manufacturing or operating organization. The student apprentice, on the other hand, enters industry from school and pursues academic study more or less in parallel with his practical training throughout a period of five or more years. Study and practical experience can be interleaved in a wide variety of ways, but one pattern which has evolved and which shows increasing practical importance is that of the sandwich course of five years duration, in which four six-month periods of full-time study are interposed between five equal periods of practical experience in industry. Recruitment to a scheme of student apprenticeship should take place normally at about the age of eighteen, the candidate having pursued sixth-form work at school and having obtained passes in mathematics and physics at Advanced Level together with five or more passes in suitable subjects at Ordinary Level of the General Certificate of Education. There is, however, provision for entry from the National Certificate course, the requirement being a 'good' Ordinary National Certificate. Thus, the boy who has left school early and has embarked upon craft or technician training is not debarred from entering upon the professional course provided that his studies have shown sufficient promise.

The successful completion of a sandwich course will normally qualify for a recognized award such as that of the recently established Dip.Tech.(Eng.) or of a college diploma. It must be emphasized that a distinctive feature of the sandwich course is the association of the industrial experience with the academic study as an integral part of the course, it being a requirement that the student should have completed his practical training satisfactorily as well as his examinations before the award is granted.

Sandwich courses are normally 'industry based', that is to say, the student is recruited by an industrial organization as a student apprentice and the firm takes responsibility for the complete planning of his industrial experience throughout the five six-month periods which he will spend in the works. This arrangement works well with large organizations within which the whole range of experience required by the apprentice can be obtained. The position of smaller firms may be less satisfactory, as an individual concern may be able to provide excellent training covering a part of the requirement but be completely deficient in respect of other portions. This difficulty is being met by group training schemes in which a number of concerns co-operate in providing full professional training facilities, and the group, in fact, accepts a collective responsibility towards the apprentices of the individual concern.

As an alternative to the 'industry based' sandwich course there is provision for 'college based' courses in which the college accepts the student and makes suitable arrangements with one or more firms to provide the full practical training required. The report emphasizes that the success of a 'college based' scheme is dependent upon the practical training being planned in conjunction with a number of firms which will undertake, as in the group training scheme, to provide, among them, for all the aspects of the full practical training. Sandwich courses represent a partnership between college and industry, and this partnership is expressed not only in administrative matters but also in the detailed co-ordination of academic and practical work. There should be close consultation between the college and the industrial firm in the planning of syllabuses for both lecture and laboratory courses. In the final year of sandwich courses it is customary for the student to carry out a fairly extensive individual investigation or special project. The report mentions that the project may well be related to the branch of industry in which the student is engaged and that its completion may sometimes be carried out in the industrial organization during the concluding phase of the student's practical training.

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* The Education and Training of Student Apprentices in Electrical Engineering: a Report of the Joint Committee on Practical Training in the Electrical Engineering Industry. Pp. 26. (London: Institution of Electrical Engineers, 1958.) 2s.

The teaching staff of the college should keep in close touch with the industrial firm by means of visits and discussions in order to ensure the proper co-ordination of practical training with studies and the maintenance of contact with students during practical training periods. It is suggested that while in the works the student should do a certain amount of directed reading with the view of widening his horizon. The history of engineering and the philosophy of science should find a place among other cultural subjects.

Sections of the report deal in outline with the education and the practical training which is expected of the professional electrical engineer, and two interesting summaries are given of the principal aims. That these are much more than mere statements of subjects to be studied and of skills to be acquired may be illustrated by two quotations. One of the items under the heading "Education" is, "to develop an understanding of the experimental method, its uses and limitations, together with a degree of skill and confidence in carrying out tests and drawing valid conclusions from the observations made", while one of the qualities which his practical training should help the electrical engineer to acquire is the "understanding of the human problems which arise in an industrial community".

Although the report emphasizes that the main route to professional qualification by student apprenticeship should, in the future, be the sandwich course, mention is made of the pursuit of Higher National Certificate courses on the basis of 'day release'. It is pointed out that the Higher National Certificate and endorsements no longer meet the educational requirements of the Institution of Electrical Engineers and two further years of part-time study are required to enable a man to sit for Part 3 of the Institution's examination or, alternatively, a special full-time course of six months duration.

The report concludes with a short section dealing with various administrative matters and an appendix summarizing the relevant regulations of the Institution of Electrical Engineers.

This publication, which, strictly speaking, is a guide to student apprenticeship, is in fact an admirable short treatise on electrical engineering as a career and the means of entering upon it. The report should be in the hands of all concerned with the education of young people. J. GREIG

THE NATIONAL PHYSICAL LABORATORY

REPORT FOR 1957

THE annual report for 1957 of the National Physical Laboratory, Teddington*, includes the report of the Executive Committee which was presented to the General Board at its meeting on May 15, 1958, the second of the annual open days of the Laboratory (see *Nature*, 182, 10 ; 1958) ; detailed reports, prepared by the respective superintendents, of the work of the nine scientific Divisions and the Test House of the Laboratory ; and, for the first time, a separate section devoted to the administration of the Laboratory and general matters.

During the year under review, the report states, the Executive Committee was mainly concerned with matters of long-term policy, particularly with proposals for the quinquennium 1959–64. Some of the recommendations have already been announced and implemented ; for example, the reorganization of the Electricity, Metrology and Physics Divisions. They are to be replaced by three new Divisions, entitled Standards (based on the Metrology Division and responsible for the fundamental standards), Applied Physics (covering secondary standards, electrotechnics, acoustics and radiology, and including the Test House), and Basic Physics (responsible for pioneering developments in non-nuclear physics of potential value to industry). New developments in most of the other divisions, including increases in their staffs, are also recommended. A new section on theoretical physics is advocated for the Mathematics Division. The Control Mechanisms and Electronics Division is encouraged to depart from the design and construction of computers and to study means of replacing, by machines, human faculties other than the ability to count. The Executive Committee is in agreement with the views of the committee set up under the chairmanship of Prof. N. F. Mott to consider the functions of the Metallurgy Division, namely, that the Division be expanded and be provided with a new building properly equipped for the mechanical working of difficult materials, though it considered that its resources should be concentrated upon a limited number of basic researches of current importance. An increase in the number of research fellowships tenable at the Laboratory, and greater flexibility in the staffing arrangements, including more temporary appointments and freedom to appoint senior men at the level appropriate to their qualifications and value to the Laboratory, would be, in the opinion of the Committee, of great benefit to the Laboratory.

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* Department of Scientific and Industrial Research. Report of the National Physical Laboratory for the year 1957. Pp. viii+122+8 plates. (London: H.M. Stationery Office 1958.) 6s. 6d. net.

The eighth in the series of international symposia, dealing with visual problems of colour, was held at the Laboratory during September 23–25. The proceedings of the symposium on the direction of research establishments which was held in September 1956; two booklets, Nos. 16 and 18, in the series "Notes on Applied Science"; and the first volume, "The Use and Construction of Mathematical Tables", in the new series entitled "NPL Mathematical Tables", were published during the year. In addition to visits to the Laboratory by numerous scientists from many countries, including two Russian parties interested in thermodynamics and the properties of steel and a group of Chinese scientists forming part of a trade delegation, the Parliamentary and Scientific Committee visited the Laboratory to see some of its work and to discuss its organization.

The Laboratory provided a number of items for inclusion in the stands of the Department of Scientific and Industrial Research at the Physical Society Exhibition of scientific apparatus, the Plastics Exhibition and the Engineering, Marine, Welding and Nuclear Energy Exhibition, and displays were shown at the Royal Society soirées and at the Geological Society of London. Seventy-two visits overseas were made by members of the staff, consisting of nine to the United States and Canada, three to Australia and the remainder to Europe.

A long-standing need at the Laboratory is a centre incorporating a first-class lecture hall, restaurant facilities and library, and it is therefore pleasant to read in the report that planning has begun for the conversion of the duplex wind tunnel building into such a centre. The first phase of the conversion will provide a lecture hall, restaurant and cafeteria, conference rooms and an exhibition hall, and the second phase possibly the rehousing of the library. The building work in connexion with the new Ship Hydrodynamics Laboratory at Feltham is proceeding satisfactorily, and that Laboratory should be in full operation by late 1959. A new workshop and a drawing office have been provided for the Aerodynamics Division, and an extension has been made to the control mechanisms building of the Control Mechanisms and Electronics Division.

The recent and more interesting activities of the various sections of the Laboratory are always illustrated and displayed during the open days, and the detailed descriptions of these given in the reports already published in *Nature* (180, 166; 1957; and 182, 10; 1958) make superfluous any additional reference to the substance of the superintendents' reports contained in the annual report. The reports, however, are well worth close study, as they indicate most clearly the very wide range of extremely careful and accurate investigations, relating to both fundamental and applied research, undertaken by the Laboratory. A bibliographical list of publications by members of the staff of the appropriate division accompanies each report. S. WEINTROUB

FIRE RESEARCH

FOR some years now, Britain has occupied a leading position in the conduct of research into fire and explosion. This is no less than is to be expected, for not only are these matters of domestic concern, but also, by reason of the world-wide nature of British insurance, there is little that happens elsewhere that is of no material interest to us.

An important stage was reached in the 1930's when the Riverdale Committee, reviewing fire brigade services in England and Wales, recommended the establishment of a Fire Prevention Research Board by the Department of Scientific and Industrial Research. Only the first practical steps had been taken when the Second World War began.

War-time experience soon showed that in air raids, damage due to fire can greatly exceed in extent that due to high-explosive bombs. For this reason, war-time fire research was developed and conducted under the ægis of the Ministry of Home Security, and a considerable number of internal and extra-mural projects were organized and brought to successful issue. After the War, the Department of Scientific and Industrial Research again assumed responsibility for fire research, and in November 1946 established, now in partnership with the Fire Offices' Committee, representing the insurance companies, the Fire Research Board and the Joint Fire Research Organization. The Fire Offices' Committee placed at the disposal of the organization its Fire Testing Station at Boreham Wood, which had been established in 1935, and this became the site of the new research station. Additional facilities, some of a temporary nature, have been acquired, and final plans for permanent buildings are now far advanced.

One further development should be mentioned. In 1955 the Fire Research Board set up a Committee on Industrial Fires and Explosions to advise with regard to research upon problems encountered by the Factory Inspectorate and others in contact with industry. This step was associated with a very desirable broadening of the interests of the organization into the field of industrial hazards.

An impression of the growth of the work as a whole is gained by comparing the first report of the Board and the Director, issued in 1947, with that for 1957*, which has recently appeared. In the intervening ten years, both the scope of the work and the staff employed have greatly increased, but it is gratifying to note that the length of the report has not increased proportionately.

The statistics with regard to fires attended by fire brigades in the United Kingdom during 1956 and the preceding years are of popular interest, and provide a background against which much of the other work must be viewed. For this reason it is a little surprising that the figures do not receive more comment in the report itself. They reveal a marked recent increase in the total number of fires; to which increase, fires in the open (grassland, heathland, woodland, embankments, refuse, etc.) have contributed most notably. So far as fires in buildings are concerned, the increase is fairly evenly spread over the different types. The most marked, however, is seen in the "other buildings" category, and, as these account for some 10 per cent of the total building fires, further analysis seems to be desirable. A similar remark applies to the analysis of electrical causes of fire where, although most of the defined categories show that the situation is at least under control, "other apparatus" is responsible for growing numbers of fires. The use of oil-burning appliances in buildings is an increasingly important cause, and attention is directed to this matter in the report, where it is pointed out that a disturbing number of fatalities is associated with fires of this type.

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* Department of Scientific and Industrial Research and Fire Offices' Committee. Fire Research 1957: Report of Fire Research Board and the Report of the Director of Fire Research. Pp. vi+52+8 plates. (London: H.M. Stationery Office, 1958.) 5*s*. net.

In a review of this character it is impossible to do justice to the considerable amount of excellent experimental work that is recorded. Mention may be made of the continuation of the fruitful investigation of the ignition of solid materials by radiated heat, and the interesting experiments on the correlation of fires in buildings with those in models. Among building materials, ordinary and pre-stressed concrete have received particular attention as to their behaviour in fire; while on the operational side, attempts are being made to put the application of fire detectors and the use of water sprays and foam as extinguishing media on a scientific footing. Work on industrial explosions has been directed particularly to the scope and limitations of explosion reliefs and flame arrestors; and a study has been made of the significance of the readings of commercial explosimeters when applied to vapours of diverse nature. Work on the flammability of fabrics is being directed to the important question of the personal hazard arising from the ignition of clothing and to the development of a relevant test. Several smaller but no less interesting investigations complete the list.

A distinct effort has been made to render this report readable and comprehensible to the general reader, even to the provision of a glossary of the special terms used. Like most Stationery Office publications, it provides excellent value for money, and it is to be hoped that it will be widely read.

J. H. BURGOYNE

ANIMAL LIFE ON WAVE-BEATEN ROCKS

By DR. H. GORVETT

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WAVE-BEATEN rocks on exposed shores appear, at first sight, to be somewhat barren and devoid of life, but recent investigations have shown that here, as in other parts of the sea-shore, there exists a surprisingly large number and variety of animals.

The richness of the microfaunas of intertidal seaweeds and lichens has been amply demonstrated[1]; animal life in rock crevices is known to be both diverse and abundant[2]; and sorting and counting the inhabitants of even a very small rock pool may well keep a dozen students on a marine biology course busy for days. But most of the work done so far on this type of sea-shore ecology has been concerned with relatively sheltered habitats, and it is interesting to discover that the surface of a wave-beaten reef, where conditions would seem to be far less hospitable, may support a microfauna almost equally rich.

The site of the present investigation is a low rocky reef extending seawards from the western shore of the island of Oronsay in Argyllshire. Oronsay is about ten miles west of the island of Jura, and its western coast is exposed to the full force of Atlantic gales. The reef is a smooth hump of rock about 80 yards long and 12 yards wide, rising gently to a flattened crest about 6 ft. above mean low-water springs. Although the conditions here are not as rigorous as in certain other localities in the Western Isles, the degree of exposure is such that few of the larger seaweeds can survive on its surface, and these only as isolated tufts separated by wide expanses of weed-free rock. In place of the luxuriant cover of weed found above low-tide level in more sheltered situations, there are only stunted specimens of the exposed shore form of *Fucus vesiculosus* (*F. vesiculosus* L., f. *linearis* (Huds.), commonly known as f. *evesiculosus*[3]), small compact cushions of the red calcareous weed *Corallina officinalis*, a few individual plants of the thong-weed *Himanthalia elongata*, and occasional small tufts of *Gigartina stellata*. Below low-tide level the rocks are coated with the red calcareous *Lithothamnion*, partly hidden by a relatively prolific fringe of fucoids, in which the species of *Laminaria* (*L. digitata* and *L. hyperborea*) are intermingled with a high proportion of *Alaria esculenta*. The latter is a weed that grows only in relatively exposed situations, and it is the only fucoid capable of withstanding conditions of extreme exposure such as are to be found on the isolated islet of Rockall[4].

The only conspicuous animals on the areas of rock surface between the weed tufts are limpets, patches of barnacles, the anemone *Actinia* (fairly common in pools and crevices), and occasional little clusters of small mussels (also in crevices). The greater part of the animal population, however, has to be searched for more carefully, since it consists of small forms living in the shelter provided by the larger organisms, more especially by the encrusting barnacles and by the cushion-like growths of *Corallina*.

If the barnacles are scraped off the rock and separated from one another under a binocular microscope, and if their skeletal plates are taken apart, a host of small animals is revealed, some living in the empty shells of dead barnacles, others in the chinks and crevices between the plates of living ones. So numerous are these that a scraping from even a small area of rock surface cannot be fully sorted in less than two or three days. The record is held at present by a patch of barnacles from the flat top of the reef about 6 ft. above mean low-water springs. This measured 5 cm. × 5 cm. (2 in. × 2 in.) and was found to contain a total of no less than 1,756 animals. These were all visible to the naked eye, and were picked out individually with forceps. Single-celled animals such as foraminiferans (which were common) were ignored, and so were many smaller members of other groups (such as nematodes). The animals counted belong to more than twenty species and are made up as follows :

Balanus balanoides	97	*Hemioniscus balani*	1
Chthamalus stellatus	55	Amphipoda	9
Turbellaria	2	*Anurida maritima*	6
Nemertinea	3	Chironomid larvæ	66
Nematoda	4	Acarina	1,056
Polychæta	19	*Littorina saxatilis*	191
Oligochæta	55	*L. neritoides*	48
Copepoda	4	*Mytilus* sp.	9
Tanaidacea	8	*Lasaea rubra*	123

The most numerous animals are the mites, of which there appear to be five species. But even if these, and the barnacles themselves, are excluded, there still remain 548 animals of other groups. Totals of more than 800 animals, excluding the barnacles and numerous but uncounted mites and copepods, have been obtained from other 5 cm. × 5 cm. samples. The most surprising animals to find inhabiting the surface of wave-beaten rocks are, perhaps, the chironomid larvæ ; but these are often common in rock pools[5] and in other parts of the shore.

The alga *Corallina officinalis* also harbours a large microfauna. In the pools this weed grows into a loose branching plant several inches high, but on the exposed rock surface it forms compact rounded humps an inch or less in height. Although the branches are short and closely packed, large numbers of small tubicolous polychætes, oligochætes, amphipods, chironomid larvæ, nematodes, and others manage to squeeze into the narrow cavities between the branches for shelter and protection.

The population of small animals appears to be considerably greater on the Oronsay reef than on the islet of Rockall, where only six species of invertebrate animal have been found[6]. But, as Dr. Crisp suggests, additional factors may be involved here, and the paucity of animal life on Rockall may be due not only to the high degree of exposure to which it is subjected but also to the island's small size and isolated position—a combination of conditions that may effectively prevent its being colonized by the settlement of the free-swimming larval stages that are produced by so many of the shore-dwelling animals.

Work is proceeding on a comparative survey of the microfaunas of wave-beaten rocks, and it is hoped that in due course it will be possible to publish elsewhere the results of this work in greater detail.

I am most grateful to Prof. H. R. Hewer for his efficient organization of a combined seal and microfauna expedition to Oronsay, and to the Royal Society for a grant from the Browne Research Fund.

[1] Colman, J., *J. Mar. Biol. Assoc. U.K.*, **24**, 129 (1940). Dahl, E., "Undersökningar över Öresund", 35 (1948). Wieser, W., *J. Mar. Biol. Assoc. U.K.*, **31**, 145 (1952).

[2] Glynne-Williams, J., and Hobart, J., *Proc. Zool. Soc. Lond.*, **122**, 797 (1952). Morton, J. E., *J. Mar. Biol. Assoc. U.K.*, **33**, 187 (1954).

[3] Powell, H. T., *J. Mar. Biol. Assoc. U.K.*, **36**, 407 (1957).

[4] Powell, H. T., and Chamberlain, Y. M., in Fisher, J., "Rockall", Appendix *B* (Geoffrey Bles, 1956).

[5] Stuart, T. A., *Trans. Roy. Soc. Edin.*, **60**, 475 (1942).

[6] Crisp, D. J., in Fisher, J., "Rockall", Appendix *C* (Geoffrey Bles, 1956).

DEPENDENCE OF THE NUCLEONIC COMPONENT OF COSMIC RAY AIR SHOWERS ON RADIUS

By C. S. WALLACE, Dr. M. M. WINN and Dr. K. W. OGILVIE

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University of Sydney

IN an experiment using a core selector and a neutron-operated detector sensitive to radiations producing small stars in lead, Marsden and Doran[1] have studied the nucleonic component in extensive showers.

A large proportion of the recorded counts of such an apparatus is due to low-energy ($\sim$ 1 BeV.) nucleons, but the thick interacting layer of lead usually used makes an estimate of the mean energy difficult. We shall describe a similar experiment, in which a more complete analysis allows us to give a density distribution of nucleons with radius r from the shower core, and more complete information about processes occurring in the detector.

The Sydney air-shower apparatus[2] allows the size, N, of showers falling within its sensitive area to be found and the positions of their cores to be determined with an accuracy of $\pm$ 4 m., using an assumed structure function and the total particle density at nine points. The direction of approach can also be obtained. To detect nucleons we used the Sydney neutron monitor, a standard International Geophysical Year apparatus of area 1·88 m.^{2}, as described by Simpson[3] which contained eleven counters at the time of the experiment.

The shower master-pulse gates pulses from the monitor into an additional scaler for a period from + 5 μsec. to + 300 μsec. after the shower. The number of neutrons counted in each event is thus recorded. A maximum of fifteen neutrons may be handled in this way, sixteen or more being recorded as a group. The proportion of accidental counts is 1 in 500 showers, and a total of 3,113 showers was observed at various times between June 1957 and May 1958.

In order to produce a recorded count, a nucleon associated with an air shower must traverse the monitor and give rise to an interaction which produces neutrons, which must then be successfully detected. Besides the real density distribution with radius and shower size, the number, energy, and direction of nucleons produced at an interaction, and the detection efficiency for the neutrons among them will be involved. The number of neutrons observed for a shower of given size at a given radius will therefore not be unique but will have a distribution. In order to extract the average density distribution we make the following assumptions :

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* Also supported by the Nuclear Research Foundation within the University of Sydney.

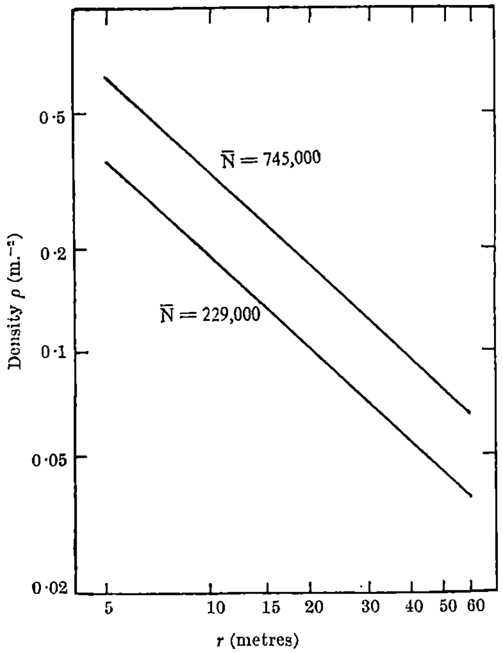

Fig. 1, Uncorrected density of nucleons as a function of r for two values of N, these being the mean values of two of our shower size classes; $2 \cdot 29 \times 10^5$ for $10^5 < N < 4 \times 10^5$ and $7 \cdot 45 \times 10^5$ for $4 \times 10^5 < N < 1 \cdot 6 \times 10^6$

(1) The number, k, of air shower nucleons interacting is a Poisson variable with mean $n(N,r)$. (2) The interaction releases a number of neutrons $M(N,r)$. We are here averaging over the energy distribution of incoming particles. (3) The detection efficiency per neutron p is independent of N and r and is small. The number of recorded counts per interaction is then a Poisson variable of mean m equal to Mp, but this is less true the larger p becomes. Thus for given N and r the probability of recording x counts in an event is :

$$P_x(m,n) = \sum_{k=0}^{\infty} P(k,n)\, P(x,k)$$
$$= \sum \frac{\exp(-n)\, n^k}{k!} \; \frac{\exp(-mk)\,(mk)^x}{x!}$$

Known values of M and p for similar structures[4] lead us to the conclusion that m is of the order of 1. The count frequency may be plotted as a histogram for a given size of shower and radius, Table 1 showing a typical example.

Table 1

No. of counts, x	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	$\geq$ 16
Frequency, a_x	133	25	14	5	4	2	2	2	1	0	0	2	2	0	0	1	2

For each such histogram a likelihood function can be formed :

$$L(m,n) = \prod_{x=0}^{16} \Big[P_x(m,n) \Big]^{a_x}$$

where a_{16} includes events with 16 or more counts and $P_{16}(m,n) = 1 - \sum_{x=0}^{15} P_x(m,n)$.

By maximizing these functions, assuming that m and n depend on some power of the radius and shower size[5], we obtain expressions for m and n valid over the region $10^5 < N < 2 \times 10^6$, 4 m. $< r <$ 60 m. These show the following features :

(1) $m = Mp$ is found to vary as $N^{0 \cdot 15 \pm 0 \cdot 05} / r^{0 \cdot 25 \pm 0 \cdot 05}$. The detection efficiency, p, for the neutrons is unlikely to vary rapidly with the energy of the incident particles. This assumes that most of the neutrons are produced by evaporation, though not necessarily in one interaction, and that their energy is a slowly varying function of the excitation energy[6]. Thus the mean energy of the particles detected decreases slowly with increasing radius and the multiplicity observed means that it is greater than about 500 MeV.

(2) The density of the particles counted is proportional to $N^{0 \cdot 47 \pm 0 \cdot 1}\, r^{-0 \cdot 92 \pm 0 \cdot 1}$ between 5 and 50 m., in fair agreement with Marsden and Doran.

(3) In Table 2 we compare our results with those of Lehane[7]. The densities in the third column are obtained by dividing our value of n for 5×10^5 particle showers at the appropriate radius by the area of the lead in the neutron monitor, and so are not corrected for the fraction of particles going through it without interaction.

Table 2

Radius (m.)	Lehane (m.$^{-2}$)	Uncorrected density (m.$^{-2}$)	Corrected density (m.$^{-2}$)
5	1·5	0·52 ± 0·1	0·79 ± 0·15
10	0·83	0·26 ± 0·05	0·4 ± 0·1
25	0·36	0·147 ± 0·01	0·223 ± 0·015
50	0·047	0·06 ± 0·01	0·09 ± 0·015

Agreement between the corrected readings, obtained by using an interaction mean free path of 184 gm./cm.^{2}, and those of Lehane is fair, but our results show a less rapid decrease with increasing radius. If the mean energy of the nucleons decreases with distance from the shower core, as is suggested by the variation of m with radius, the rate of Lehane's penetrating-particle detector would be more affected than that of our apparatus. A calculation, using the cross-section for production of stars by μ-mesons extrapolated to ground-level[8] and the density of μ-mesons found by Lehane, shows that production of stars by μ-mesons cannot produce this discrepancy. Similarly, production of neutrons by μ-mesons stopping in the lead produces too small an effect, and we regard the most likely explanation to be the sensitivity of the monitor to neutrons with an energy of several MeV., many of which are likely to be scattered to the outer regions of an extensive air shower.

We wish to acknowledge a grant from the Australian Academy of Science for the construction of the neutron monitor, and to record our appreciation of the excellent laboratory and computational facilities provided by Prof. H. Messel.

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SEPARATION AND CHARACTERIZATION OF TWO COERULOPLASMINS FROM HUMAN SERUM

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THE serum constituent coeruloplasmin has recently been discussed as a factor possibly connected with mental diseases[1,2]. The application in this field of research of a well-known histochemical oxidase reagent, dimethyl-*p*-phenylene diamine, provides a convenient photometric method for estimating the enzymic activity of this protein[3] which contains copper. Oxidase measurements on serum have, however, little, if any, value as a diagnostic tool[4]. Many etiologically different diseases, and normal pregnancy, are characterized by increased levels of coeruloplasmin[5]. In some quarters this increment is assumed to be adaptive to an enhanced production of biologically active metabolites, the rapid destruction of which is essential for normal function. A precise knowledge of the physiological significance of coeruloplasmin is, however, still lacking.

With the exception of the work of Uriel *et al.*[6], no attempts have been made so far to separate the serum proteins and to compare their ability to oxidize dimethyl-*p*-phenylene diamine or related substances. This communication gives a brief description of a series of experiments based on the general assumption that the oxidation of dimethyl-*p*-phenylene diamine by whole serum is brought about by several more or less related enzymes, independently. Serum was fractionated with a calcium phosphate column and the existence of two chromatographically different oxidizing enzymes was demonstrated with the use of an improved technique, which excludes irrelevant influence from contaminating non-enzymic copper. Finally, it has been demonstrated that combinations of certain organic acids and chloride ions are powerful inhibitors of coeruloplasmin, a fact which has certain physiological implications.

The starting material used was serum from in-patients at a mental asylum. The subjects chosen were not undergoing heavy treatments at the time of sampling, such as insulin, chlorpromazine or electric shock.

The oxidase activity measurements were performed as follows. (This work was done independently of that of Humoller *et al.*[7], which was only recently brought to my notice.) Stock solution I was prepared by dissolving 3·120 gm. of dimethyl-*p*-phenylene diamine dihydrochloride (No. 3067, Merck, Darmstadt) and 3·72 gm. of the disodium salt of ethylenediamine tetraacetic acid (Hopkin and Williams Ltd., Chadwell Heath, Essex) in 50 ml. of 4 *N* hydrochloric acid and diluting with distilled water to 100 ml. Solution I was stored in plastic tubes at about −20° C. Stock solution II was a triethylamine–acetic acid buffer with *p*H 5·5 (0·50 *M* with respect to triethylamine, 0·58 *M* with respect to acetic acid). The substrate solution used was made up from 1 ml. of solution I and 50 ml. of solution II diluted with distilled water to a volume of 250 ml. The final *p*H was about 5·3 at 20°. Depending on the range of the oxidase concentration expected in the fractions, aliquots of 10–200 μl. were pipetted into suitable test-tubes and placed in an ice-bath. Using a semi-automatic syringe[8], 2 ml. of the cooled substrate solution was rapidly distributed into each test-tube. The whole set of tubes was then placed in a 37° C. thermostat for 10 min. and afterwards transferred to ice water, where it remained during the reading of the extinction at 552 mμ, using a 1·0 cm. cell and a Beckman *B* spectrophotometer. Usually 12 blanks without enzyme and 6 standard samples were included in each set.

The function of the ethylenediamine tetraacetic acid is to suppress the non-enzymic oxidation of the substrate which is mainly due to contaminating cupric ions. Copper forms a chelate with ethylenediamine tetraacetic acid in the molar ratio of 1 : 1, and at *p*H 3·5 or higher the chelation is almost complete[9].

Fig. 1 shows that the blank activity (open squares) is practically abolished by concentrations of ethylenediamine tetraacetic acid higher than about 10^{-6} *M*. This corresponds to the expected level of copper contamination in water and chemicals. That cupric ions do have a relatively intense oxidizing effect on dimethyl-*p*-phenylene diamine is demonstrated by the crossed-square curve, which was obtained with $4 \cdot 75 \times 10^{-5}$ *M* cupric chloride in the substrate. Ethylenediamine tetraacetic acid concentrations higher than the equivalent to this amount again suppress the catalytic activity. Thus, the cupric ethylenediamine tetraacetic acid chelate has no ability to oxidize dimethyl-*p*-phenylene diamine.

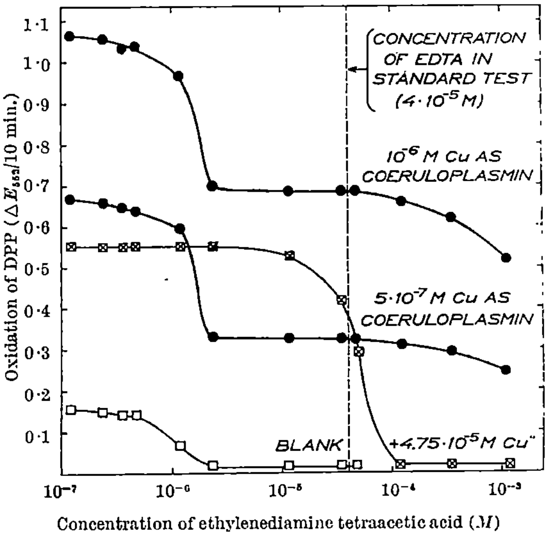

Fig. 1. Effect of different concentration of ethylenediamine tetraacetic acid on the oxidation of dimethyl-*p*-phenylene diamine. □—□, No additions; ×—×, $4 \cdot 75 \times 10^{-5}$ *M* cupric chloride; ●—●, with two different concentrations of coeruloplasmin

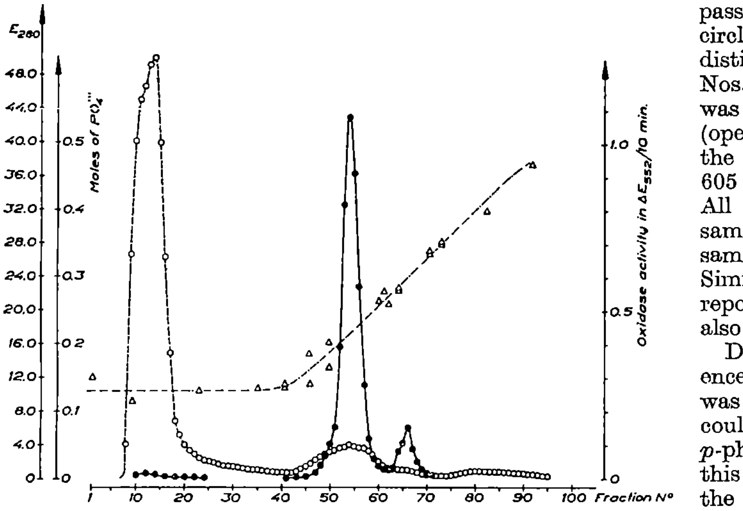

Fig. 2. Gradient elution chromatography of 9 ml. of serum on a column with 11·2 ml. of hydroxylapatite. Fraction volumes about 1·5 ml. ○—○, extinction at 280 mμ; ●—●, oxidase activity; △, phosphate concentration

Experiments with iron indicated that ethylenediamine tetraacetic acid had no influence whatever on the comparatively moderate oxidation of dimethyl-*p*-phenylene diamine brought about by added quantities of ferric chloride (cf., however, Green *et al.*[10]). The question remains open whether or not ethylenediamine tetraacetic acid is able to counteract a possibly increased catalytic activity of metal-protein complexes of non-enzymatic character, notably those with copper[11]. Fig. 1 demonstrates also that 4×10^{-5} *M* ethylenediamine tetraacetic acid has no inhibitory effect on the enzymatic oxidation of dimethyl-*p*-phenylene diamine by coeruloplasmin (black circles). This concentration of ethylenediamine tetraacetic acid was used in the standard test for the oxidase activity and is quite sufficient to suppress the catalytic blank oxidation commonly met with. Fig. 1 shows also that, during standard conditions, a doubling of the coeruloplasmin concentration will give rise to approximately twice the extinction at 552 mμ (black circles).

The chromatographic fractionation of the serum was carried out with a calcium phosphate (hydroxylapatite)[12] column, chiefly because of its high capacity for coeruloplasmin[13]. The column here used contained 11·2 ml. of hydroxylapatite (4·2 gm. dry weight) and the chromatogram was developed with a linear gradient of phosphate buffer, produced with an open mixing chamber and a conical depot flask[14]. At the start of the experiment, the column was in equilibrium with 0·125 *M* phosphate buffer and the mixing chamber contained 65 ml. of the same buffer, while the depot flask was filled with 250 ml. of 0·66 *M* phosphate buffer of the same *p*H, 6·8. With a hydrostatic pressure of about 130 cm. the flow rate was around 2 ml. per hr. Before the application to the column, the serum was dialysed against a 0·125 *M* potassium phosphate buffer of *p*H 6·8 for about 20 hr. Both dialysis and chromatography were carried out in a cold room at +4° C. Fig. 2 shows a typical result when 9 ml. of dialysed serum were chromatographed under these conditions. The readings of the extinction at 280 mμ for the different fractions (open circles) show that the bulk of the serum proteins are not adsorbed but appear as a large peak (fractions Nos. 9–16) immediately after the dead volume has passed. All the oxidase activity (black circles) was retained and appeared as two distinct zones (with maxima in fractions Nos. 54 and 66). The outcoming gradient was checked with phosphate determinations[15] (open triangles). Both the oxidases showed the same spectrum with maximum at 605 mμ, characteristic of coeruloplasmin[16]. All other sera investigated have shown the same oxidase heterogeneity and about the same proportion between the two peaks. Similar types of heterogeneity have been reported for many enzymes and recently also for another oxidase[17].

During attempts to find enzymic differences between these two coeruloplasmins, it was observed that certain organic acids could act as powerful inhibitors of dimethyl-*p*-phenylene diamine oxidation. Moreover, this inhibition seemed to be conditioned by the pretreatment of the coeruloplasmin. Fig. 3 illustrates the effect of varying concentrations of maleic (*A*), fumaric (*B*), salicylic (*C*), and oxalic acids (*D*) on the oxidase activity of a coeruloplasmin preparation, which had been dialysed for about 44 hr. against a 0·9 per cent sodium chloride solution. Phthalic acid caused an inhibition of the same order as did salicylic acid. If, however, the same amount of the identical coeruloplasmin was dialysed for 44 hr. against 0·125 *M* potassium phosphate buffer, *p*H 6·8, no significant inhibition could be demonstrated (curve A_1). Dialysis against 0·2 *M* sodium acetate buffer, *p*H 5·7, also prevented the inhibiting effect of maleic acid. In all these experiments the inhibitor was mixed with the coeruloplasmin about one hour before the determination of the activity, during which period it was stored at +4° C.

The effect of ions on the coeruloplasmin inhibition has several physiological implications; in particular, it appears that the control mechanism of the oxidase activity *in vivo* may be of a similar nature. It is hoped to treat this problem, as well as possible correlations with clinical data, during further investigations.

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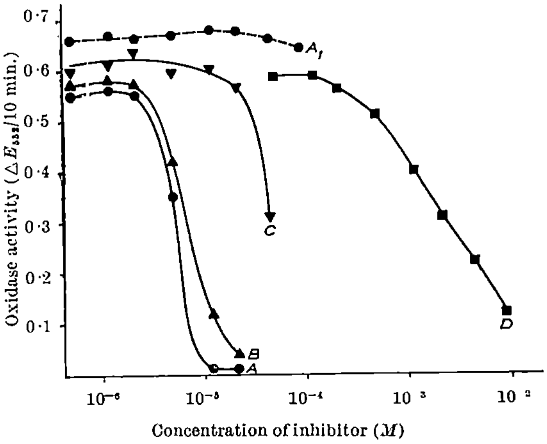

Fig. 3. Inhibition of coeruloplasmin by different organic acids (*A*, maleic; *B*, fumaric; *C*, salicylic; *D*, oxalic) and the coeruloplasmin dialysed against 0·9 per cent sodium chloride. Curve A_1 with maleic acid and the coeruloplasmin dialysed against 0·125 *M* potassium phosphate buffer

Swedish Medical Research Council. My thanks are due to Dr. H. G. Boman for many stimulating discussions and to Profs. A. Tiselius and B. Jacobowsky for their kind interest.

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PROTOPLASMIC STREAMING AND WALL STRUCTURE IN *NITELLA*

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DURING the course of work in progress on the cell wall structure of the alga *Nitella opaca* Ag., some observations have been made which may have a bearing on the mechanism of orientation of the cellulose component in the wall of this alga.

The internodes of *Nitella opaca* Ag. are large single cells, the mature cells of which may be several centimetres long. When the wall of a living *Nitella* cell is viewed with a hand lens, two colourless lines in an otherwise uniform green layer of stationary chloroplasts are visible. These lines are on opposite sides of the cylindrical wall and are so directed as to make a right-hand spiral around the wall. When viewed under a microscope at a higher magnification, it is obvious that the stationary chloroplasts are in regular files and that these files are approximately parallel to the two colourless striations. In the living cell, streaming of the protoplasm can be clearly seen, and it is apparent that the direction of streaming is the same as that in which the files of chloroplasts are arranged. On one side of the cell the protoplasm is streaming upwards, and on the other side it is streaming downwards, and the clear lines, revealed as narrow regions in which there are very few chloroplasts, are the boundaries between the ascending and descending streams.

The angle between the files of chloroplasts and the cell axis (which is a fairly accurate measure of the direction of protoplasmic streaming), has been measured for a number of internodal cells at various stages of growth, and it has been found that there is a correlation between the streaming angle of the protoplasm and the dimensions of the cell. In Fig. 1 the length/diameter ratio (l/d) is plotted against cot θ, where θ is the angle between the files of chloroplasts and longitudinal axis of the cell (so that θ is the streaming angle). The correlation between l/d and cot θ is highly significant. The correlation coefficient (R) is 0·91 (at the 0·001 level of significance, R = 0·617 for 23 degrees of freedom).

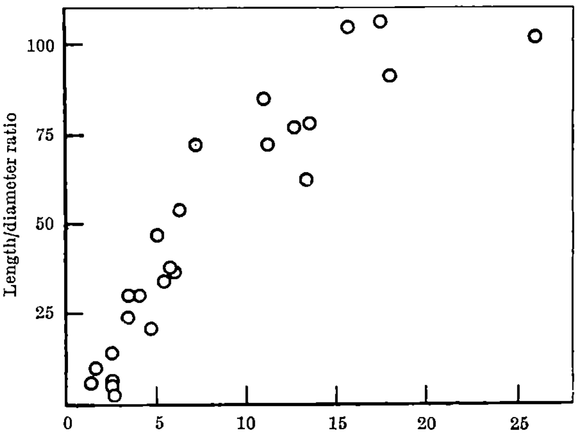

Fig. 1. Length/diameter ratio plotted against cot θ, where θ is the (streaming) angle between the files of chloroplasts and the longitudinal axis of the cell. Each point refers to a separate cell

The regression equation is of the form,

$$l/d = a + b \cot \theta$$

where θ is the streaming angle, l the length of cell, d the diameter of cell and a and b are constants. There is some evidence, however, that this linear relation is only an approximation, and that the actual relation is rather more complex.

Since the direction of protoplasmic streaming is so well defined, *Nitella* is an ideal material to examine for any correlation with cellulose chain direction in the cell wall. Since the streaming angle is a function of cell dimensions (and, therefore, of the age of the cell) it is possible to obtain cells with a wide range of streaming angles by selecting cells varying in age from the very young to the mature. The appropriate observations have therefore been made on a series of cells of various ages. The streaming angle was measured on the living cell. The major extinction position of a single cell wall with respect to the cell axis was measured with a polarizing microscope in the following way. The ends of the cell were cut off at an oblique angle to the cell axis, the protoplasm removed by stroking the cell gently under water, and the cell mounted on the slide in dilute glycerine. Because the cell was cut obliquely to the cell axis it was possible to mount it in such a way that when flattened by the cover-slip a fairly large area of single cell wall was visible at each end of the cell (Fig. 2).

It was found that the direction of the major extinction position followed a flat helix around the cylindrical wall, and that the helix angle varied with the age of the cell and, therefore, with the streaming angle and also with the dimensions of the cell. The results are shown graphically in Fig. 3. The correlation between streaming angle and angle of major extinction position is highly significant. The correlation coefficient (R) is 0·85 (at the 0·001 level of significance, $R = 0{\cdot}617$ for 23 degrees of freedom).

These latter results are in contradiction to those obtained by Green and Chapman[1] for *Nitella axillaris* Braun. They state that "Structural investigations reveal that the cellulose microfibrils of the wall are well oriented and run strictly in the transverse direction. This orientation is found in all portions of the wall and in all stages of its development". Unless there is a genuine difference between these two species there seems to be a conflict here. An apparent displacement of the major extinction position from its true position can of course arise through, for example, a misalignment of the cross-wires in the microscope. Fig. 2 is designed to show that no such error is a contributing factor in the present case and fully to document the helical arrangement of the major extinction position. In Fig. 2*a* the double wall (on the left) is extinguished while the single wall (on the right) is bright; in Fig. 2*b* the single wall is extinguished while the double wall is bright. A moment's thought will satisfy the reader that the major extinction position of the single wall must be tilted to the transverse. It seems that the wall of *Nitella axillaris* Braun should be re-examined in the light of these results. The matter is of some importance for two reasons. First, the observed correlation between streaming angle and major extinction position raises once again the question of the part played by streaming in the orientation of the anisotropic particles being incorporated in a new wall layer. It was observed many years ago by Denham[2] that the directions of protoplasmic streaming and of wall striations were often identical, and on this basis he suggested mechanisms whereby streaming might cause orientation in cell walls. Although this idea attracted considerable attention at the time and led to a good deal of speculation, the subsequent observation by Martens[3] that the striations concerned lay deep in the wall and not on the inner face, against the cytoplasm, led to an abandonment of the whole concept which was perhaps premature. The correlation observed here is not quite of the type suggested by Denham, since the streaming direction and the wall major extinction position tend to lie at right angles to each other. Moreover, since the chloroplasts are stationary, it does not seem likely that the cytoplasm near the wall is in movement. It could be, however, that the proteins of this surface layer are oriented by the streaming of those inner regions of the cytoplasm in which movement does occur and that these in turn are responsible for wall orientation. The present observations offer no evidence on this point. Secondly, it is possible that the phenomenon of spiral growth exhibited by these two species of alga might be more simply explained in terms of the type of spiral structure we have described for *Nitella opaca* Ag., than it could be if the major extinction position, as stated for *Nitella axillaris* Braun, is indeed strictly transverse; perhaps along the lines already suggested for the sporangiosphores of *Phycomyces*[4–6].

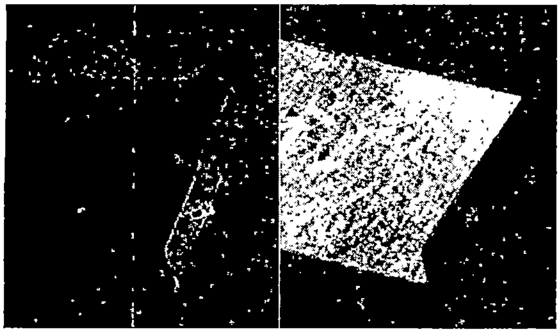
(*a*) (*b*)

Fig. 2. Cell wall of *Nitella opaca* Ag. photographed between crossed nicols (× 75). In Fig. 2*a* the double wall (on the left) is extinguished while the single wall (on the right) is bright. In Fig. 2*b*, after a rotation of the cell through 14 deg., the single wall is extinguished while the double wall is bright. The major extinction position of the wall is clearly not transverse

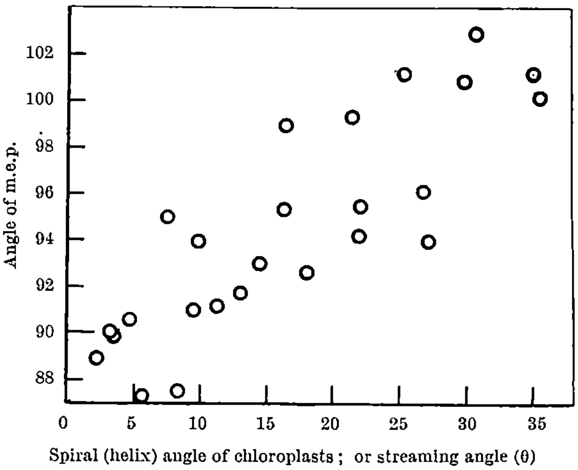

Fig. 3. Angle of major extinction position plotted against spiral helix angle of chloroplasts, or streaming angle θ. Angles are measured with respect to longitudinal axis of cell. For angles less than 90°, the major extinction position and the streaming angle are so directed as to make a right-hand spiral around the wall; for angles greater than 90° the spiral is in the left-hand sense

It has been shown that there are correlations both between cell dimensions and streaming angle and between streaming angle and the angle of the major extinction position of the cell wall. There will, therefore, also be a correlation between the angle of the major extinction position and cell dimensions. It is interesting to recall that a correlation between cell dimensions and the angle of the major extinction position has been shown to exist for some other types of plant cell, namely, conifer tracheids, bamboo fibres, and sisal fibres[7]. It does not, however, seem appropriate at this time to speculate as to whether these similar phenomena owe their existence to similar growth mechanisms.

We wish to acknowledge our indebtedness to a New Zealand National Research Fellowship grant to one of us (M. C. P.) which is enabling this work to be carried out.

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LETTERS TO THE EDITORS

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Nuclear Magnetic Resonance Spectra from a Crystal rotated at High Speed

Hindered molecular rotation in solids reduces the width of their observed nuclear magnetic resonance spectra, with a consequent decrease in the measured second moments[1]. By contrast, on general theoretical grounds it has been shown[2] that the second moments of dipolar-broadened spectra should remain invariant and should not be reduced by such motion. In a recent explanation[3] of this apparent discrepancy the nuclear magnetic interaction was divided into two parts, namely, a steady mean interaction and a fluctuating part. The steady mean interaction is less than the interaction in a static crystal devoid of hindered rotation and generates an observed spectrum narrower than that of the static crystal. The fluctuating part of the interaction generates side-spectra set at integral multiples of the frequency of molecular rotation on either side of the central narrowed spectrum. Since the molecules do not rotate uniformly, but are re-oriented with an irregular motion, these side-spectra are dispersed over a band of frequencies with an intensity too weak to be observed. It was shown, however[3], that when these weak side-spectra are included the second moment does indeed remain invariant even though the second moment of the central portion, which is all that is observed experimentally, becomes smaller.

Since this explanation requires the existence of side-spectra which are too weak in intensity normally to be seen, it seemed desirable to devise an experiment which would render them observable. If all the molecules in a solid were to rotate with the same uniform frequency, the side-spectra would then be centred at well-defined frequencies and should, under suitable conditions, have sufficient intensity to be observed. The most convenient way in which to achieve this situation is to take a crystal within which there is no appreciable motion of the nuclei and to rotate it uniformly. In this way all nuclei in the crystal rotate with the same uniform frequency with respect to their neighbours. Since the accepted criterion[1] for spectral narrowing is a rotation-rate at least comparable with the width of the spectrum, it was clear that a high speed of rotation would be necessary.

Using an air-driven rotor, a single crystal of sodium chloride was spun at speeds up to 50,000 revolutions per minute about the [001] direction in a magnetic field of 6,000 gauss directed normally to the axis of rotation. With this geometry it may readily be shown[3] that side-spectra should occur only at even multiples of the rotation frequency ν_r on either side of the narrowed central spectrum. Examples of the sodium-23 resonance derivative spectra recorded with a modified Pound–Watkins spectrometer are shown in Fig. 1. The first-order side-spectra are clearly seen at the highest rotation-rates and occur, as predicted, at a separation of $2\nu_r$ from the centre of the spectrum. The central portion is approximately halved in width as the theory requires for this case. There is good general agreement between the shape of the derivatives recorded and those calculated, at all rates of rotation. In particular, at the highest rate of rotation (800 c./s.), where the first side-spectra are well resolved, their intensity relative to that of the central portion is in satisfactory agreement with theory. At 800 c./s. the expected relative intensity of the second side-spectra at $\pm 4\nu_r$ is less than 1 per cent, and they have not been observed.

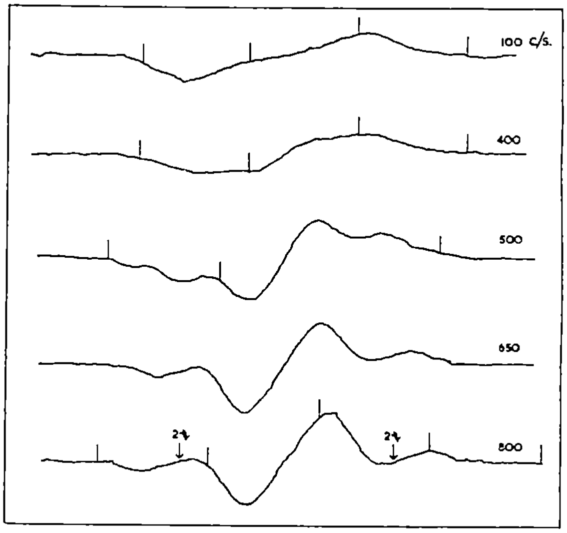

Fig. 1. Sodium-23 nuclear magnetic resonance derivative spectra of a single crystal of sodium chloride rotated at the rates indicated. The markers on the recordings are 1,660 c./s. apart

The second moments of spectra recorded at different rotation-rates are given in Table 1; the rotation-rates were measured photoelectrically.

Table 1

ν_r (c./s.)	Second moment (gauss^2)	ν_r (c./s.)	Second moment (gauss^2)
100	0·57	500	0·55
200	0·54	700	0·56
400	0·57	800	0·59

The mean theoretical value of the second moment for the static crystal with the magnetic field in the (001) plane has been found from Van Vleck's formula[4] to be 0·55 gauss^2. This value is in satisfactory agreement with the results in Table 1 and verifies the invariance of the second moment.

This experiment shows in a direct manner that the relative rotation of nuclei in solids does cause a narrowing of the nuclear magnetic resonance spectrum. Moreover, in addition to demonstrating the presence of side-spectra and verifying the invariance of the second moment within the limits of the experimental uncertainty, the experiment also shows directly that for spectral narrowing the necessary rate of nuclear motion is of the order of the spectral width. (The r.m.s. line-width 0·74 gauss is equivalent to 833 c./s.)

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Transmission Electron Microscopy of Beryllium

We have prepared thin films of beryllium in which it is possible to observe directly the arrangements of dislocations and other structural defects by transmission electron microscopy. The films were made by two methods.

Beryllium was deposited as thin (0·03–0·05 mm.) polycrystalline flake on cool surfaces from metal melted by electron bombardment. This flake was etched in a dilute aqueous solution of hydrofluoric and nitric acids to give specimens suitable for examination. The grain-size was about 1μ. Single-crystal specimens were prepared by cleaving a beryllium crystal parallel to the basal plane to obtain a flake which was ground and polished down to a thickness of 0·02 mm. and then etched. Specimens were examined using 70-kV. electrons in the prototype Metropolitan-Vickers *E.M.*6 electron microscope.

Grain boundaries and single perfect dislocations were clearly visible in the evaporated flake. Many grains were structurally perfect while others contained several dislocations. From the electron-optical fringes on the grain boundaries the films were shown to be several thousand angstrom units thick.

A low-magnification electron micrograph of a single-crystal thin film is shown in Fig. 1. The long, sharp, roughly parallel lines make a $[1\bar{1}00]$ trace on the basal plane. From this and the fact that they make a line-projection on (0001), it may be concluded that they are either due to single dislocation lines or to $[11\bar{2}0]$ planes. As the difference in contrast on either side of them is often quite marked (it is similar to that on crossing a well-formed sub-boundary in aluminium[1,2] or germanium[3]) there must be a considerable misorientation associated with them. Furthermore, the contrast on them is higher than that usually associated with single dislocations ; they are therefore planes of a $(11\bar{2}0)$-type. X-ray and conventional metallographic techniques have revealed the existence of $\{11\bar{2}0\}$ planes which are effectively tilt boundaries, and which are believed to be important in the fracture mechanisms observed in beryllium[4]. At points such as *A* in Fig. 1, a boundary with a $[1\bar{1}00]$ trace is observed to end in a fan-like array of dislocations. This can be understood if this boundary consisted of dislocations parallel to the basal plane. Coupling the X-ray and metallographic evidence with the present observations one may conclude that the boundaries consist of edge dislocations stacked normal to the basal plane. It is yet to be determined whether these boundaries ('bend planes') are formed during the growth of the crystal from the melt or during cleavage.

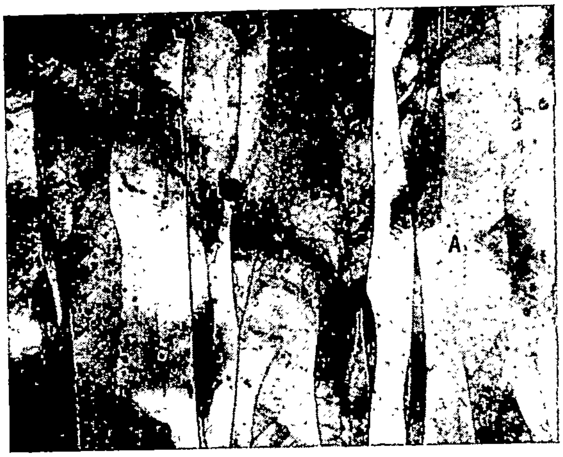

Fig. 1. Bend planes and dislocations in beryllium. At *A* the constituent dislocations of a bend plane fan out into an array. (× 4,000)

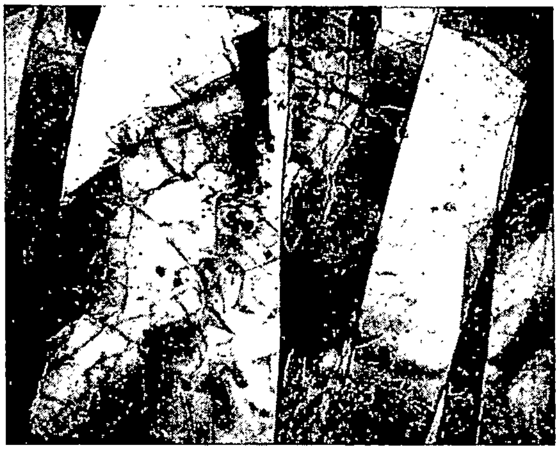

Fig. 2. Bend planes, dislocations and dislocation loops in beryllium. (×40,000)

Between the sharp parallel lines in Fig. 1 there are randomly oriented lines believed, on the basis of similar studies of other materials, to be perfect dislocations more or less in the plane of the specimen. Fig. 2 shows bend planes and single dislocations at a higher magnification. Closed loops of dislocation line also occur ; these are probably due to the condensation of vacancies during solidification. The same mechanism probably accounts for the highly kinked nature of some of the dislocations.

The dislocation density in the single crystal was about 10^8/cm.^{2} : most of these dislocations were probably 'grown in'.

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Dispersion of the Stress Optical Coefficient of the Alkali Halides

In recent years the dispersion of the stress optical coefficients of diamond[1], the alkali halides[2] and magnesium oxide[3] has been determined in the visible range of wave-lengths. The dispersion in fused quartz[4,5] has also been investigated from 5700 to 2500 A. The observed dispersion is of the order of a few per cent for all these materials. In the present investigation the dispersion of the stress optical coefficient $C = n^3(q_{11} - q_{12})/2$ has been determined from the visible range to 2400 A. The method of measurement combines the differential feature of Bansigir and Iyengar's[2] method with the photo-

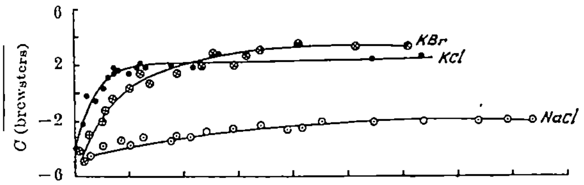

Fig. 1. Dispersion of the stress optical coefficient $C = n^3(q_{11}-q_{12})/2$ of three alkali halides

graphic method of Jog[6]. Using fused quartz (presented by the Thermal Syndicate to Prof. R. S. Krishnan) as the standard, the stress optical coefficient of the alkali halides is obtained by determining the position of the dark bands in the spectrum of light polarized at 45° to the direction of stress and passed through the fused quartz specimen loaded suitably, the stressed alkali halide crystal and an analyser in the crossed position. The position of the dark bands is determined by the equation:

$$C_1W_1/t_1 + CW/t = n\lambda$$

where C is the stress optical coefficient of the material for wave-length λ; W is the load applied on it; t is its thickness and n is the order of the band. C_1, W_1 and t_1 refer to the standard and C, W and t to the alkali halide used.

In Fig. 1 are given the curves depicting C as a function of wave-length. As the method is differential, the accuracy in determining C is not very high. For sodium chloride, the mean square deviation of the experimental points from the curve is 0·16 brewsters while for potassium chloride and bromide it is 0·3 brewster. In Table 1 the values of $(q_{11}-q_{12})$ at 4800 A. determined in the present investigation are compared with the values in the literature.

Table 1. $(q_{11} - q_{12}) = 2C/n^3$ FOR THE ALKALI HALIDES (VALUES IN BREWSTERS)

Substance	Present value	Value in lit.	Reference
Sodium chloride	− 1·12	− 1·17 − 1·18	2 7
Potassium chloride	1·42	1·47 1·85 1·37	2 8 7
Potassium bromide	1·76	1·76 1·70 1·58	2 7 9

From the curves we see that: (1) in the visible region the dispersion is only a few per cent in agreement with the observations of Bansigir and Iyengar; (2) as one approaches the ultra-violet, the dispersion becomes enormous; for example, in sodium chloride C varies from −1·9 at 5800 A. to −4·5 brewsters at 2500 A., in potassium chloride from +2·4 at 5000 A. to −2·0 brewsters at 2450 A. and in potassium bromide from +3·4 at 4800 A. to −4·6 brewsters at 2450 A.; (3) the curves for potassium chloride and bromide show that the stress optical coefficient for these crystals changes sign at 2550 A. and 2760 A. respectively. It therefore appears that these crystals which belong to Mueller's[10] class IV ($q_{11} - q_{12}$ +ive; q_{44} −ive) go over to Mueller's class II ($q_{11} - q_{12}$ −ive; q_{44} −ive Ex. sodium chloride) as one moves into the ultra-violet.

Further work is in progress, and the results will be published later.

My thanks are due to Prof. R. S. Krishnan for his interest, to the Thermal Syndicate, Ltd., England, for the gift of the fused quartz specimen and to the National Institute of Sciences of India for a research fellowship.

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Thermal Contact at Low Temperatures

MECHANICAL heat switches are becoming of increasing importance in low-temperature calorimetry, and in order to study thermal contact both for this practical application and from interest in the mechanism of heat transfer, we have built the apparatus sketched in Fig. 1. This differs from the apparatus described by Berman[1] mainly in the method of applying the load by a screw, and measuring it by strain gauges cemented to the cantilever.

Our first experiments were on copper, and two typical load cycles are shown in Fig. 2. At 18° K. the conductance, Q (the heat flow per unit temperature difference across the junction), is proportional to $\sqrt{W}$, where W is the load. At 4° K. the power of W is slightly higher, and the absolute values and the dependence on load agree very closely with Berman's results. The dependence on temperature of the conductance, shown in Fig. 3, is smaller than was found by Berman.

From experiments on electrical contact[2], it has been found that the radius of the microjunctions,

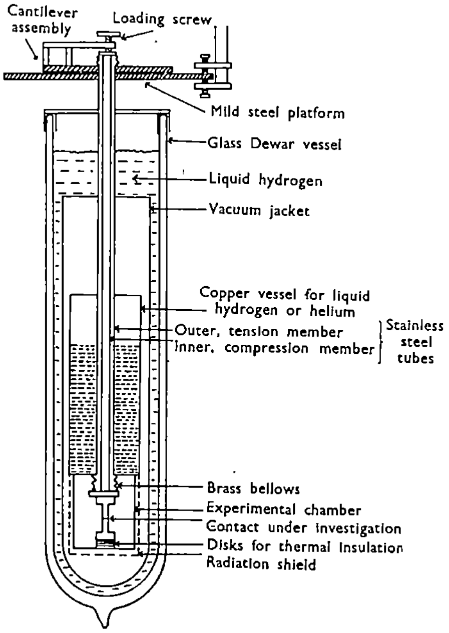

Fig. 1. Schematic diagram of contact apparatus

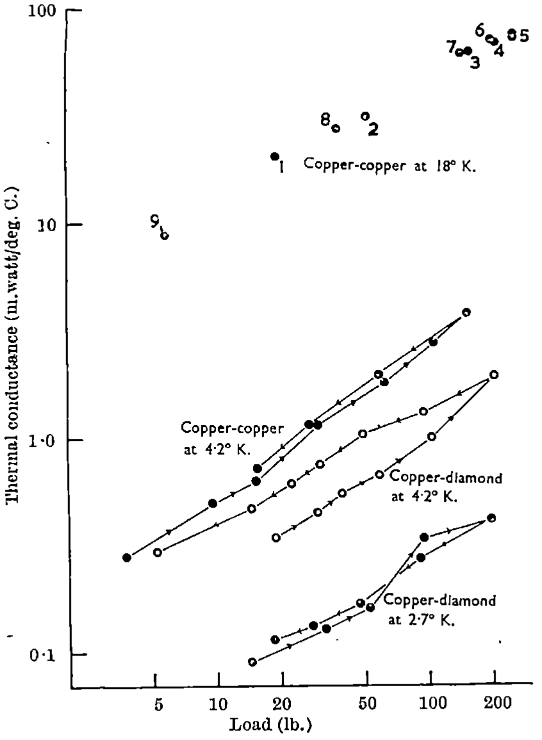

Fig. 2. Variation of thermal conductance with load after contact had been broken at the working temperature. (Numbers or arrows indicate the order in which measurements were made)

where true contact between metals occurs, is of the order of 10^{-2} cm. Even at 4° K., both the electron and phonon mean free paths in copper are not more than 10^{-3} cm., so that the theory of a spreading resistance[3] should apply. A junction of radius r in a material of bulk thermal conductivity κ presents a thermal resistance $1/2r\kappa$, so that, for n junctions in parallel:

$$Q = 2nr\kappa$$

The total area of real contact, A, is determined by the yield pressure of the material, P. For plastic deformation of the asperities, as would occur for an increasing load:

$$A = n\pi r^2 = W/P$$

whence:

$$Q = 2\kappa(nW/\pi P)^{1/2}$$

Tabor has shown that for steel, n varies roughly as $\sqrt{W}$, so that for increasing load Q should vary roughly as $W^{3/4}$ in reasonable agreement with our results. If the asperities deform elastically on reducing the load, $A \propto W^{2/3}$ and Q should vary as $W^{0\cdot 6}$. For the load cycles on copper there is, however, no significant difference between the two parts of the cycle.

If we modify Tabor's results on steel to take into account the lower yield pressure of copper, we would expect that for a load of 100 lb. applied at room temperature, $n \sim 20$ and $r \sim 10^{-2}$ cm. From the observed value of Q, κ at 4° K. would be 2×10^{-2} watts/cm. deg., which is remarkably close to the lattice conductivity of copper at this temperature.

The measured electrical conductance is of the order of 100 times smaller than corresponds to the heat conductance, suggesting that the microjunctions are between oxide layers on the asperities of the surfaces, with pure copper only in contact over a small fraction of the area. The oxide layer is, however, very thin compared with the size of the microjunctions, so that the electronic conductivity should be effective over the greater part of the constriction. As, in addition, the lattice heat conductivity varies as T^2, while the conductance measured in these experiments varies as $T^{1\cdot 3}$, the similarity between the derived value of κ at 4° K. and the lattice conductivity must be regarded as fortuitous.

There is evidence[4] that any non-metallic film on gold is broken at very small loads, and the whole contact is then electrically conducting. We have, therefore, measured the conductance of a gold contact, and the results at a load of 100 lb. are shown in Fig. 3. The electrical conductance was too high to be measured with our existing arrangement, but the thermal conductance was equivalent to less than 10 times our limit of measurement of electrical conductance.

As a gold–gold contact at helium temperatures is 25 times better than a copper–copper contact, we intend to examine the effect of gold-plating the copper rods, to avoid the oxide layer.

In a non-metallic crystal at low temperatures, the phonon mean free path can be several millimetres, and is thus much greater than the size of the surface asperities. We would, therefore, expect the junctions to act as apertures for radiation-like heat flow (this treatment of heat flow in crystals when the mean free

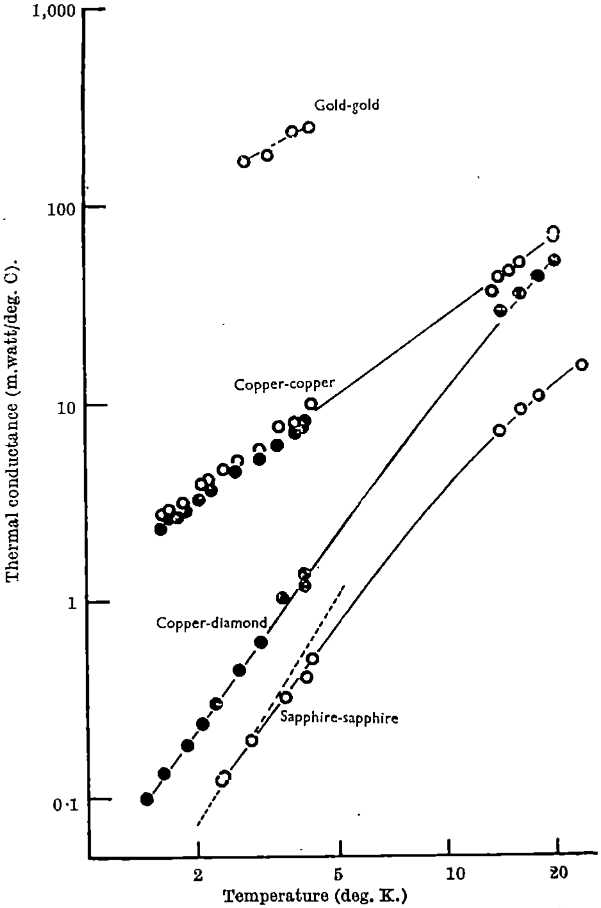

Fig. 3. The variation of thermal conductance with temperature at a load of 95 ± 5 lb., applied at room temperature. The measurements on the copper–copper contact at helium temperatures were made on two different days. ----, $Q = 9 \times 10^{-6}T^3$ watts/deg. C.

path is long has been used by Casimir[5]) and for apertures of zero thickness, $Q = \frac{1}{4}C_v/vA$, where C_v is the specific heat per unit volume and v is the mean phonon velocity. We have measured the contact between two artificial sapphire crystals, and the results for a load of 100 lb. are shown in Fig. 3. Using the hardness to determine A for this load applied at room temperature, the above equation gives $Q = 11 \times 10^{-6}T^3$ watts/deg. C. From 'talysurf' examination, the asperities are seen to have a height equal to about one-quarter of their diameter, and this would reduce the conductance by about 20 per cent. We therefore expect to find $Q \sim 9 \times 10^{-6}T^3$ watts/deg. C. This calculated curve is shown in Fig. 3 and can be seen to agree quite well with the experimental results, both in absolute magnitude and in the temperature variation. At the lowest temperatures, the experimental curve should probably be lowered by about 10 per cent because of heat leaks, which are significant at these low values of conductance. We have not made this correction as its value is uncertain, but it would certainly increase the slope of the experimental line.

Finally, we may mention that we were interested by the fact that the heat capacity of diamonds has been measured at low temperatures in a copper calorimeter without exchange gas[6]. We measured the thermal contact between two copper rods separated by a small diamond, and found that the conductance lies between that for two pieces of copper and the conductance between two rods of a hard substance like sapphire. The values shown in Figs. 2 and 3 are double the measured conductances and represent a single copper–diamond contact. The short equilibrium time in the heat capacity experiments must, therefore, be entirely due to the high thermal diffusivity of diamond at low temperatures, and is not related to any unusual properties of a diamond–copper contact.

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Effect of the Carrier Gas on the Sensitivity of a Thermal Conductivity Detector in Gas Chromatography

IT appears to be a popular belief that the use of hydrogen or helium as the carrier gas in gas chromatography gives the highest sensitivity with a thermal conductivity detector, because the difference in thermal conductivity between organic vapours and hydrogen or helium is greater than for any other carrier gas[1,2]. This is not necessarily true, however, for the difference in temperature between the hot wire (at t_1° C.) and the body of the thermal conductivity cell (at t_0° C.) is inversely proportional to the thermal conductivity K_1 of the carrier gas :

$$t_1 - t_0 = a/K_1, \text{ where } a \text{ is constant.}$$

If the concentration of organic vapour in the carrier gas is x, the sensitivity of the detector is proportional to :

$$\frac{dt}{dx} = -\frac{a}{K_1^2}\cdot\frac{dK}{dx}$$

When x is small, dK/dx is approximately equal to $K_1 - K_2$, where K_2 is the thermal conductivity of the organic vapour.

$$\text{Hence } \frac{dt}{dx} = -\frac{a(K_1 - K_2)}{K_1^2}, \text{ approximately.}$$

Thus the sensitivity of the detector is inversely proportional to the square of the thermal conductivity of the carrier gas, and directly proportional to the difference in thermal conductivity. It follows that the carrier gas with the lowest thermal conductivity will give the highest sensitivity ; this has been confirmed experimentally by comparing the peak heights obtained from the same size of sample with helium and with argon carriers. The apparatus was a Griffin and George Mk. IIA V.P.C. apparatus, the sample was a mixture of equal parts of methane, ethane, and propane, and amounts ranging from 0·01 to 0·1 ml. were injected ; the relative sensitivities in terms of peak height (in.) per ml. of each gas were calculated from the average of six determinations with each carrier gas and the results were as shown in Table 1.

Table 1. RELATIVE SENSITIVITIES, AS PEAK HEIGHT (IN.) PER ML. OF HYDROCARBON GAS

Hydrocarbon	Helium carrier	Argon carrier
Methane	116	311
Ethane	98	190
Propane	25	28

Of the commoner inorganic gases, carbon dioxide (thermal conductivity $1 \cdot 37 \times 10^3$ ergs per cm. per sec. per deg. C.)[3], nitrous oxide ($1 \cdot 44 \times 10^3$) and argon ($1 \cdot 58 \times 10^3$) are likely to give the best results with thermal conductivity detectors in gas chromatography ; sulphur dioxide ($0 \cdot 77 \times 10^3$) and hydrogen sulphide ($1 \cdot 20 \times 10^3$) are probably too reactive to use as carrier gases except in special circumstances.

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A Detector for Use with Capillary Tube Columns in Gas Chromatography

A RECENT development in gas chromatography is the use of columns made from metal capillary tubing, the inner surface of which is coated with a thin layer of stationary phase[1]. These columns promise greatly enhanced performance and resolution in the separation of volatile substances compared with the conventional packed-powder columns ; for optimum performance, however, capillary tube columns require small-bore tubing, a thin layer of stationary phase and a slow rate of gas flow, approximately 1 ml./min The small dimensions of these columns necessitate small loads in the region of 1 μgm. of the mixture to be separated, otherwise the stationary phase would bear excessive concentrations of the various components and the resolution of the column would suffer. The slow rate of gas flow combined with the outstanding resolving power of the columns causes the emergence of the more volatile components in a gas volume of only a few μl. These two properties of the capillary tube columns impose severe restrictions on the type of detector suitable for observing the emergence of vapour from the column. The smallness of the load demands high sensitivity, and the smallness of the retention volume demands a detector with a sensing volume at least as small. A detector was reported in which the concentration of vapour molecules emerging from the column was measured in terms of their ionization following collisions with metastable rare-gas atoms[2]. This detector is more than sufficiently sensitive for use with the capillary columns; it is, however, much too large (1–10 ml.) and cannot simply be scaled down in size to accommodate the requirements of the capillary columns. This communication describes a modified version of the detector with a sensing volume in the region of 1 μl.

The large-volume detector previously described consisted of an ionization chamber containing a source of ionizing radiation sufficient to provide a saturation current, usually in argon, of 10^{-8} amp. The carrier gas was led directly from the column into the ionization chamber. The electrons set free in the gas by the radiation were accelerated by the potential imposed on the chamber to velocities sufficient to excite a proportion of the argon atoms to their metastable state; the ionizing collisions between these excited atoms and the vapour molecules as they emerge from the column were observed as an increase in ionization current. The relatively large volume of this detector was determined principally by the fact that the primary ionization current was the product of the gas volume and the radiation intensity; very small volumes would require excessive radiation intensities. If, however, in this detector the anode is made small compared with the dimensions of the chamber the greater part of the electric field will reside close to the anode surface; thus the only region of the detector in which the primary electrons will be sufficiently accelerated to excite the argon atoms will be that in the immediate vicinity of the anode. This small volume then constitutes the sensing volume of the detector.

Fig. 1 illustrates a practical device based on this notion. It consists of an ionization chamber of similar dimensions to that previously described with the earlier detector, for example, 1 cm. diameter by 1 cm. deep. Gas from the column is led into the chamber along a narrow metal capillary tube which could be the end of the column itself. Within the chamber the capillary tube is enclosed in a sleeve of insulating material, polytetrafluoroethylene, the end of this sleeve being widened to form a small cylindrical chamber 1 mm. in diameter by 1 mm. deep. One end of this small chamber is open to the main chamber, and the metal capillary tube terminates at the base. The anode consists of a small bead fused on to the end of a short length of gold wire; the wire is inserted into the bore of the capillary tube until the bead is enclosed by the small chamber. The capillary tube, of course, serves as the electrical connexion to the anode. When a sealed source of ionizing radiation, for example, 10 mc. of strontium-90 or 80 μc. of radium *D*, is inserted in the main chamber and a potential of between 500 and 1,000 V. applied between the anode and cathode, the argon carrier gas is excited to its metastable state almost entirely within the confines of the small sensing chamber. To prevent slow changes in response caused by the reaction of vapour molecules with the smaller concentration of excited atoms in the outer chamber a scavenging flow of argon at, say, 50 ml./min. is passed through the outer chamber. Alternatively, a lesser scavenging flow or some other gas, say, dry air or nitrogen, may be used. These gases are both able to discharge the metastable argon atoms without producing ions and so limit the response to the small chamber where argon and vapour alone are present; they do nevertheless serve as efficient sources of primary electrons when irradiated by the sealed source.

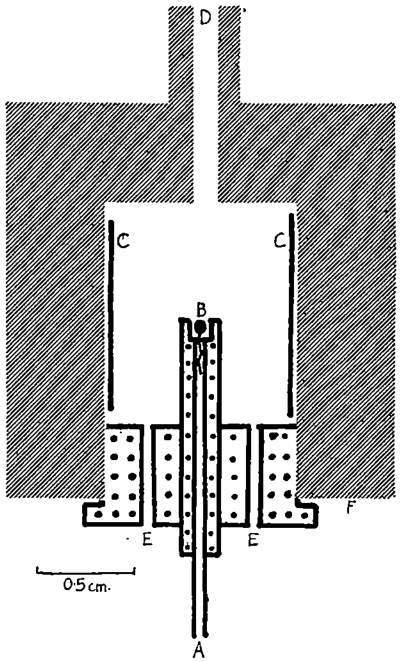

Fig. 1. The small-volume detector; details of construction: (*A*), inlet for gas from the chromatograph column; (*B*), anode; (*C*), source of ionizing radiation; (*D*) and (*E*), inlet and outlet for the scavenging gas; (*F*), cathode. Shaded, brass; stippled, polytetrafluoroethylene

The detector here described has been tested with a metal capillary column 125 ft. long, 0·01 in. in diameter and with a thin layer of squalane as the stationary phase. An efficiency of 30,000 theoretical plates was observed in the separation of a mixture of hydrocarbon vapours using a load of 0·3 μgm. The response of the detector is closely similar to that reported for the large-volume device both in terms of sensitivity and response to different substances. It is insensitive to small changes in temperature and pressure, but rather more sensitive to rate of gas flow. The response is linear with vapour concentration provided a series resistance of between 1 and 5×10^9 ohms is included in the source of applied potential.

I am indebted to Mr. D. H. Desty of British Petroleum, Ltd., for the loan of the capillary column and for his help and advice in its use.

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Formation of Higher Bromo-Complexes of Tervalent Gold in Non-Aqueous Solution

TERVALENT gold is usually four-covalent in its compounds and possesses a square-planar arrangement associated with $5d6s6p^2$ bonding[1]. Complexes of gold(III) with a co-ordination number greater than four have recently been prepared by Harris and Nyholm[2]. These compounds are of the types $[Au(diarsine)_2X](ClO_4)_2$ and $[Au(diarsine)_2X_2]ClO_4$ (where X = Br or I and diarsine = *o*-phenylene*bis*-(dimethylarsine)). Bivalent palladium and platinum, which possess a similar d^8 electronic configuration, also exhibit co-ordination numbers greater than four with this ligand[3,4].

Harris, Livingstone and Reece[5] have recently reported the formation of the hexabromo-palladate(II) ion in nitrobenzene solution. The reaction of bromide ions with the tetrabromoaurate(III) ion has now been examined in non-aqueous solution. The $[AuBr_4]^-$ ion resembles the $[PdBr_4]^{2-}$ ion in that its absorption in nitrobenzene solution in the visible region is lowered by the addition of bromide ions. A continuous variation study (Fig. 1) in this solvent, using a differential spectrophotometric method[5], gives a maximum optical density depression near a ratio of two bromide ions to one $[AuBr_4]^-$ ion. This suggests the formation of the $[AuBr_6]^{3-}$ ion in this solution.

Measurements were also made on this system in nitromethane solution (Fig. 2). The use of this solvent enabled the absorption spectrum to be measured at shorter wave-lengths and the effect of much higher bromide concentrations to be studied. The $[AuBr_4]^-$ ion possesses a very broad absorption maximum in nitromethane ($\lambda_{\max.} = 394$ mμ; ε = 4,850). At high bromide concentrations, the intense red-brown colour of dilute solutions of this ion is discharged with the formation of a very pale yellow solution of the $[AuBr_6]^{3-}$ ion ($\lambda_{\max.} = 379$ mμ; ε = 550). It is possible that species such as $[AuBr_5]^{2-}$ and $[Au_2Br_{10}]^{4-}$ are also formed in this reaction, and this is being further investigated. In this connexion it is interesting to note that Bjerrum and Kirschner[6] have shown that $[Au(SCN)_5]^{2-}$ and $[Au(SCN)_6]^{3-}$ ions are formed in concentrated aqueous thiocyanate solutions containing tervalent gold.

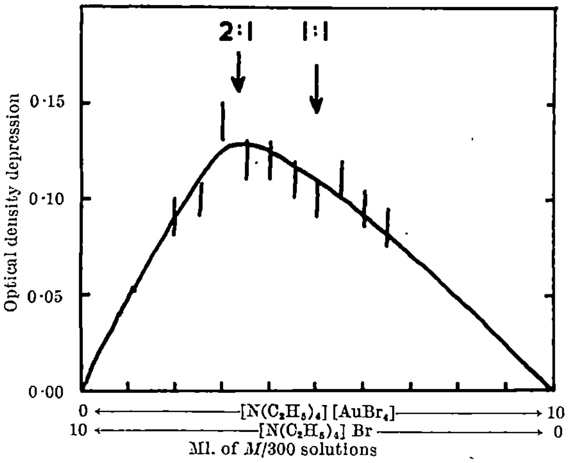

Fig. 1. Continuous variation study on nitrobenzene solutions of tetraethyl ammonium tetrabromoaurate(III) and bromide ions at 430 mμ in 0·50-cm. cells at 12° C. The theoretical end-points are shown

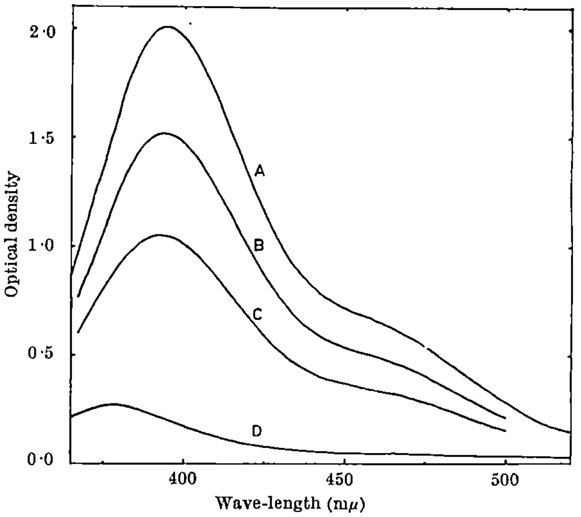

Fig. 2. Absorption spectrum of the tetrabromoaurate(III) ion in nitromethane solutions containing various concentrations of tetraethylammonium bromide. Cell size, 0·50 cm. *A*, *M*/1,200 tetraethylammonium tetrabromoaurate(III); *B*, solution *A* plus 0·1 *M* bromide; *C*, solution *A* plus 0·25 *M* bromide; *D*, solution *A* containing 0·5–0·7 *M* bromide, corrected for absorption by tetraethylammonium bromide

The formation of six-covalent gold(III) complexes such as $[Au(diarsine)_2X_2]ClO_4$ has been attributed to the use by the gold atom of two additional elongated $6p6d$ bonds normal to its usual $5d6s6p^2$ square-planar arrangement[3]. Six-covalent species such as the $[AuBr_6]^{3-}$ ion would be expected to possess a distorted octahedral structure due to the repulsion effect of the filled $5d_z{}^2$ non-bonding gold orbital which points along the axis of the two additional Au—Br bonds. Such a distorted octahedral arrangement for gold(III) has been observed by Elliot and Pauling[7] in the structure of the compound $Cs_2[Au^{III}Cl_4][Au^{I}Cl_2]$. Here, each gold(III) atom is surrounded by four chlorine atoms at 2·42 A. with two further chlorine atoms (from $[AuCl_2]^-$ ions) at 3·1 A.

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Use of Iron-52 as a Radioactive Tracer

Two radioactive isotopes of iron, namely, iron-59 (half-life 45 days) and iron-55 (half-life 3 years), have been used extensively for tracer investigations in medical and biological studies. We should like to direct attention to another isotope of iron, iron-52, the physical characteristics of which may be of advantage in some investigations.

The half-life of iron-52 is quoted in the literature as 7·8 hr. [1] and 8·3 hr. [2], and our measurements give a figure of 8·4 ± 0·1 hr. The isotope decays by K-capture or by positron emission, the maximum energy of the positrons being 0·8 MeV[3]. The branching ratio is 60 per cent electron capture to 40 per cent positron emission[4]. All disintegrations give rise to a gamma-ray of 170 keV. (Coleman, C. F., private communication, 1958). The great majority of them result in the formation of manganese-52 (isomeric state), which decays with a half-life of 21 min. directly to chromium-52, giving a gamma-ray of 1·46 MeV.[5]. The maximum energy of the positrons produced in this latter process is 2·6 MeV. A small proportion of the events (not more than 5 per cent) produce manganese-52 in the ground-state which decays to chromium-52, with a half-life of 6 days, so that the activity of the ground-state manganese-52 produced is very small, and its presence may be ignored or a minor correction applied.

Iron-52 has been prepared in the Medical Research Council cyclotron at Hammersmith Hospital, by bombarding natural chromium with 30 MeV. alpha-particles, the reaction being chromium-50 (α, 2n) iron-52. Samples of the resulting iron-52 have been separated chemically, initially by Dr. P. Reasbeck and afterwards by one of us, giving specimens of high specific activity. However, during the bombardment the isotope iron-55 is also produced, by the reactions chromium-53 (α, 2n) iron-55 and chromium-52 (α, n) iron-55, the relative amount formed depending on the α-particle energy and the target thickness used. Since, however, iron-55 produces no radiation other than a K-capture X-ray of 6 keV., it is possible to measure the radioactivity in counting systems insensitive to this isotope. Its presence does, however, increase the radiation dose delivered to the subject, and must be remembered when human applications are being considered.

It is necessary to consider how far the suitability of iron-52 for biological tracer investigations is affected by the unstable nature of its daughter product. In many experiments this will be of little consequence. This is so when the material which is being measured can be isolated from active metabolic changes, as in the case of plasma samples in blood-clearance studies. Here, provided the specimen is left for an hour, to ensure that the manganese-52 (isomeric state) is in equilibrium with the iron, the activity of the sample depends solely on the iron metabolism of the system from which it was obtained. Measurements of plasma clearance, using iron-52, in various animals have shown the expected exponential patterns. In one animal, a dog, the test was repeated a few days later, using iron-59, when a very similar result for the time of half-disappearance was obtained.

However, if measurements are to be made while metabolic changes are occurring, as, for example, in the case of *in vivo* surface counting, the possibility arises that a different metabolism and distribution of the daughter isotope will confuse the iron studies. There is as yet little information available on the fate of atoms formed in tissue as a result of radioactive decay. When using iron-52 it is clearly very important to know if the manganese-52 (isomeric state) remains at the site of its formation for a time long compared with its half-life, so that the observed distribution of radioactivity will be characteristic of the distribution of the iron. We have made a limited investigation of this problem by injecting some iron-52 intravenously into several rats. Some six hours later the rats were killed and various organs (liver, spleen, kidney, femur, etc.) rapidly resected. The activity in the organs was then followed to see if there was any change occurring with a half-period of 20 min., such as would occur if the daughter product were out of equilibrium with its parent. No such change of activity was observed in any of the specimens studied. It seems probable, therefore, that in these animals the major part of the manganese-52 (isomeric state) decayed at the sites of its formation. If the same is true in man it will then be possible to use iron-52 for *in vivo* studies.

The fact that iron-52 is a positron emitter may be of use when accurate location of the activity is desired because coincidence-counting techniques on the annihilation radiation would be possible. It may thus be possible to give sufficient of the isotope to enable studies to be made of the distribution and volume of erythropoietic tissue, a point of great importance, for example, for the dosimetry of phosphorus-32 therapy in polycythæmia and other hæmatological conditions.

The advantages of iron-52 derive principally from its short half-life. This implies that in tests for which the isotope is suitable a smaller integral radiation dose may be given to the patient. Unfortunately the integral radiation dose given when iron-52 is used is increased by the presence of the iron-55. Initial measurements indicate that the level of iron-55 activity is unlikely to exceed 50 per cent of that of the iron-52 obtained, and it may be possible to reduce this by modifications in the production techniques. The specific γ-ray emission of iron-52 and manganese-52 (isomeric state) in equilibrium is 16, and we consider that a dose of 3 μc. of iron-52 is sufficient for plasma clearance studies if the samples are counted in a well-type scintillation counter. This would result in a maximum radiation dose to the blood of the patient of about 15 mr. from the iron-52, and, assuming a 600-days effective half-life, of approximately 200 mr. from the iron-55. This compares with approximately 300 mr. from 3 μc. of iron-59, though because of its lower specific γ-ray emission more than this quantity would be required to give similar counting accuracy.

The principal value of iron-52 appears to lie in the fact that it enables studies of plasma iron turnover and early surface counting to be repeated at short intervals. It must be remembered, however, that studies of iron absorption and of red cell utilization are not possible with this isotope as they require a period of days or weeks for completion. Serial tests using iron-52 should considerably simplify the study of various problems such as the effects of ionizing radiations, applied generally or locally, and of cytotoxic substances on erythropoiesis. Similarly, the effect of altered physiological conditions on iron metabolism and the value of treatment techniques in cases of abnormal iron states could be elucidated.

The different physical properties of iron-52 make it possible for it to be used in conjunction with iron-59 in double labelling experiments.

We should like to thank Dr. C. A. P. Wood and Mr. G. R. Newbery for encouragement and advice. We are grateful to the cyclotron team for their work in producing the isotope. We are indebted to Mr. W. J. Dempster, Dr. I. Doniach and Dr. C. Osorio for advice and help with the animal experiments. The work of one of us (L. S.) has been conducted with the aid of a grant from the British Empire Cancer Campaign.

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Use of Ion Exchange Resins in preparing Water of High Purity

A recent communication[1] directed the attention of research workers to the fact that de-ionized water could contain traces of colloidal polyelectrolytes derived from the anion exchange resin, and that the presence of such particles in the effluent could have an effect upon the properties of monolayers and impose a positive charge upon the walls of glass cells.

In the vast majority of applications the presence of minute traces of organic nitrogenous material is of no practical significance, and the remarkable ionic purity of mixed-bed de-ionized water, coupled with the ease of its preparation and its cheapness, makes it far more attractive than distilled water, which nearly always contains carbon dioxide and silica together with varying significant traces of metallic ions.

Where 'pure' water is required for work of the most critical nature, a mixed-bed ion exchange column may be used providing certain precautions are taken.

In the first place, fresh resins as obtained from manufacturers should not be used. In particular, the anion exchange resin should first be eluted and then alternately regenerated with caustic soda and exhausted with sodium chloride solution two or three times. In this way, degenerated nitrogenous materials remaining on the resin from the manufacturing process are removed. The cation exchange resins should be similarly treated by being passed through the hydrogen–sodium cycle.

After complete regeneration the resins should be thoroughly washed with distilled water (100 gallons/cu. ft. anion resin and 75 gallons/cu. ft. cation resin) at a flow rate of 0·5 gallon/cu. ft./min. and should then be intimately air-mixed in the proportion 2 anion resin : 1 cation resin, by volume.

The column should be of polyethylene, 'Perspex' or 'Pyrex' (not soda glass) and should be not less than 3 in. in diameter. A minimum of depth of bed of 24 in. should be used. In a narrow column the resin-glass interface surface–volume ratio is poor and in a short column the contact time at the optimum flow rate is inadequate. The bottom filter should be of close-woven nylon or of a similar material, or else consist of a No. 1 porosity sintered 'Pyrex' disk.

The effluent should be passed through a further small column containing sulphonated polystyrene resin in the hydrogen form cross-linked 1–2 per cent. Alternatively, the filter may take the form of a 'Pyrex' or polyethylene tube loosely packed with platinum wool maintained at a high negative potential above earth.

A particle of water introduced at the top of a column may reach the bottom in any of the following three ways: (1) by migration through the interstitial bead lattices; (2) by leakage between the beads; (3) by leakage between the resin column and the container walls.

Of these three methods of transit the first is clearly the only desirable one, and the probability of this method of transit occurring is favoured by using a column having a large volume–wall surface ratio and an adequate length.

In the lowest resin zones the column ceases to behave as a mono-bed owing to the random distribution of resin beads, with the result that binary and tertiary groups formed by the degeneration of quaternary ammonium groups may hydrolyse and go into solution. The cation resin filter will remove such components either by surface effect or by ion exchange, with the production of water. Colloidal particles of anionic resin will tend to be similarly adsorbed. Such particles will also be attracted to and retained upon a negatively charged surface.

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The instructions which Mr. Raleigh has given for preparing de-ionized water of high purity are valuable and timely; they should be of interest to research workers in many fields. Evidently, with a little extra trouble one can now consistently prepare water of markedly higher purity than is commonly obtained from small laboratory mixed-bed columns, and research workers requiring water of extremely low ionic content should obviously take this extra trouble. But caution is still needed in using such water for critical studies.

First, the conductivity of the water should always be checked, using an apparatus suitable for resistivities around 5–20 megohm. cm.$^{-1}$ (which many conductivity meters are not), and its value should be stated in published work as proof of the quality of the water. The 'best' de-ionized water[1,2] has a conductivity of about 0·07 μmho cm.$^{-1}$ at 20° C., compared with 0·1–0·5 commonly obtained from small mixed-bed columns. I suggest that 'high quality de-ionized water' be defined as having a specific conductivity of not more than 0·1 μmho cm.$^{-1}$.

Secondly, our original warning[3] against the use of de-ionized water for research *in surface chemistry* must still stand, even for high-quality water. The reason is that it still contains unknown, uncontrolled traces of surface-active substances of high molecular weight. In ordinary de-ionized water these impurities can be detected by chemical analysis and by their effects on surface tension and on the surface charge of glass. The amounts present in high-quality water are doubtless much smaller, but they constitute an insidious source of danger because they can accumulate at certain surfaces. A rough calculation of the mass of a monolayer sufficient to lower the surface tension of water in a Langmuir trough by 1 dyne cm.$^{-1}$ (an easily measurable effect) shows that it amounts to only about 0·006 part per million parts of the underlying water. Since there is no means of guaranteeing absence of organic impurities down to this infinitesimal concentration (the impurities possibly including weak electrolytes), the only safe course is entirely to avoid using de-ionized water in critical research in surface chemistry. Triply-distilled water condensed in silica, having a conductivity of, say, $0\cdot3$ µmho cm.$^{-1}$, is preferable to de-ionized water of conductivity $0\cdot07$ µmho because the trace impurities in the distilled water are not highly surface-active whereas those in the de-ionized water are.

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Photosynthesis of Amino-Acids from Paraformaldehyde involving the Fixation of Nitrogen in the Presence of Colloidal Molybdenum Oxide as Catalyst

APART from the various physico-chemical methods used in industry for the fixation of atmospheric nitrogen, it is well known that quite a number of micro-organisms[1] are able to fix under mild conditions a considerable quantity of atmospheric nitrogen. In this bacterial fixation, it has been observed that molybdenum takes a prominent role[2] as a catalyst.

The possibility of achieving amino-acid synthesis without the help of micro-organisms has involved also some aspects of the problem of the origin of life. Oparin[3], Urey[4] and Bernal[5] have stressed the idea that life is based upon organic compounds which were formed when methane, ammonia, water and hydrogen were the components of the atmosphere. Miller[6] succeeded in testing this hypothesis, producing amino-acids synthetically by circulating methane, ammonia, water and hydrogen past an electric discharge.

Bahadur[7] observed that when an aqueous mixture of paraformaldehyde and potassium nitrate, in the presence of ferric chloride as a catalyst, is exposed to sunlight, about a dozen amino-acids are formed in it. We have now investigated the possibility of nitrogen fixation without the help of bacteria and subsequent utilization of the fixed nitrogen in the formation of amino-acids, in an aqueous mixture containing paraformaldehyde as the source of carbon and colloidal molybdenum oxide as catalyst, by merely exposing the mixture to a 500-W. electric light.

To detect amino-acid formation, we used circular paper chromatography[8]. The sensitive ninhydrin test for amino-acids was helpful in detecting even a trace of amino-acids formed in the experiments. Heating the paper on an electric heater helped in developing the rings of even those amino-acids which were present in extremely small quantities.

Two mixtures each containing 5 gm. of paraformaldehyde, 200 c.c. of distilled water and 10 c.c. of colloidal molybdenum oxide were prepared in 500 c.c. conical flasks. The flasks were plugged with cotton-wool and sterilized. To be sure that there was no trace of any amino-acid as impurity in the mixture at the beginning, a sample of each was tested chromatographically. Both the mixtures gave negative results. One of these flasks was covered with a thick black cloth, and both were then kept 45 cm. below a 500-W. electric bulb and exposed to light for 600 hr.

After exposure, both mixtures were tested for sterility and chromatographically for the presence of amino-acids. The circular chromatograms of the mixture exposed to light showed the presence of rings with R_F values of glycine, alanine, valine, histidine, glutamic acid, aspartic acid and ornithine, according to our calibration. Of these, the glycine and alanine rings were very distinct, whereas the other amino-acid rings were faint. Chromatograms of the mixture which was kept covered with black cloth and was thus deprived of the influence of light showed extremely faint rings of glycine and alanine.

The above experiment is consistent with the hypothesis that paraformaldehyde when mixed with colloidal molybdenum oxide and water and exposed to light fixes atmospheric nitrogen, and this fixed nitrogen soon appears as amino-acids in the mixture. This conclusion is dependent on the results obtained by use of a chromatographic method which is considered quite definite for identification of amino-acids. We are trying now to provide additional evidence of amino-acid photosynthesis.

We are grateful to Dr. R. Bianco for his assistance in various phases of this work.

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Influence of Amino-Acids on Actinomycin Biosynthesis

A NUMBER of nutritional and cultural factors have been shown to influence the qualitative and quantitative nature of the actinomycin mixture produced by a given *Streptomyces*[1–5]. In particular, the nitrogen source supplied may affect the composition of the complex formed[5]. Generally, it has been possible to change the proportion of any particular component in a natural mixture to a limited degree; in a few instances, however, a component normally produced in small amounts may increase to the extent that it represents the major constituent of an actinomycin complex. For example, we have observed[6] that actinomycin-V was the major component in the actinomycin mixture produced by *Streptomyces antibioticus* when L-threonine was sole nitrogen source, whereas actinomycin-IV represented the main constituent when L-glutamic acid was employed[3]. Schmidt-Kastner has shown that actinomycin-IV (C_1) increased from 10 to 83 per cent of the actinomycin mixture formed by *S. chrysomallus* when 0·5 per cent DL-valine was added to a glycerol–nitrate medium[5].

In the course of an investigation of the biosynthesis of the actinomycins produced by a strain of *S. antibioticus*, we have made observations regarding the marked influence of suitable amino-acids upon the relative amount of any one of the naturally produced actinomycins. The technique employed has been the following. Washed cells of the organism, previously grown in *N–Z* amine medium for 48 hr. on a rotary shaker at 28° C., were inoculated into a chemically defined medium composed of (per cent): D-galactose, 1·0; L-glutamic acid, 0·2; K_2HPO_4, 0·1; $ZnSO_4 \cdot 7H_2O$, 0·0025; $MgSO_4 \cdot 7H_2O$, 0·0025; $CaCl_2 \cdot 2H_2O$, 0·0025; $FeSO_4 \cdot 7H_2O$, 0·0025; distilled water, *p*H 7·2–7·3. When production of actinomycin began (1–2 days) a given concentration of an amino-acid (0·001–0·25 per cent) was added to a number of flasks of the growing culture. After an additional production period of three to seven days, the actinomycin mixture synthesized was harvested and the actinomycins present were separated by means of a circular paper chromatographic technique previously described[7]. The actinomycins separate as yellow zones on a papergram, thus facilitating their detection. The relative percentages of components in a mixture were determined by a spectrophotometric method[3].

As revealed in Table 1, actinomycin-IV represents the major component of the actinomycin complex produced by *S. antibioticus* in the glutamic acid medium. Addition to the medium of one or another amino-acid, for example, hydroxy-L-proline, sarcosine N-acetylglycine, or L-*iso*leucine, brought about significant quantitative changes in the actinomycin complex synthesized. Components normally produced in small or even trace amounts were found, under the specific conditions now employed, to represent major constituents of such mixtures. Moreover, not only was the nature of the amino-acid important, but also the level added to growing cultures was significant in bringing about the changes observed. Results obtained in an experiment using different concentrations of sarcosine are presented in Table 2.

The precise role of an amino-acid in modifying the biosynthetic reactions leading to actinomycin formation is unknown at the present time. The actinomycins represent a group of chromopeptides[8,9], and, therefore, an amino-acid might be incorporated directly into certain actinomycin peptides or be serving as a precursor for one naturally produced in limited amounts. Possibly it may interfere with the incorporation of an amino-acid into certain peptides, thereby inhibiting their formation and enabling greater synthesis of others instead[5]. Additional studies are necessary to learn how an amino-acid influences the reactions concerned with formation of this group of antibiotics.

Table 1. INFLUENCE OF AMINO-ACIDS ON ACTINOMYCIN SYNTHESIS

Medium	Concentration of amino-acid added (percent)	Relative percentage of actinomycin components					
		I	II	III	IV	V	*
1 Glutamic acid medium	0·0	6·4	2·3	3·2	68·3	17·2	2·6
2 Glutamic acid medium + hydroxy-L-proline	0·25	31·0	3·8	7·1	25·3	30·0	3·0
3 Glutamic acid medium + sarcosine	0·05	9·1	25·6	35·0	24·4	5·9	0·0
4 Glutamic acid medium + N-acetylglycine	0·25	8·1	2·0	3·2	32·7	51·1	3·0
5 Glutamic acid medium + L-*iso*leucine	0·25	4·7	2·8	5·8	17·2	30·6	38·9

* Denotes an unidentified component which moves faster than component V in circular paper chromatography.

Table 2. INFLUENCE OF SARCOSINE CONCENTRATION ON ACTINOMYCIN SYNTHESIS

Concentration of sarcosine added (per cent)	Relative percentage of actinomycin components				
	I	II	III	IV	V
0·0	6·2	2·1	2·8	80·4	8·4
0·001	5·3	9·2	11·9	63·5	10·1
0·005	6·5	21·2	30·8	35·9	5·6
0·05	9·1	25·6	35·0	24·4	5·9

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A New Synthesis of the Pentapeptide L-Histidyl-L-Phenylalanyl-L-Arginyl-L-Tryptophyl-Glycine and its Melanocyte-stimulating Activity

A SYNTHESIS of the pentapeptide H.His-Phe-Arg-Try-Gly.OH along classical lines has recently been described by Hofmann *et al.*[1]. The amino-acid sequence of this peptide, which occurs in adrenocorticotropic (ACTH) and melanocyte-stimulating (MSH) hormones[2], presents a number of considerable difficulties for chemical synthesis, chiefly owing to the presence of tryptophan, arginine and histidine. In this communication, we wish to report the synthesis of this pentapeptide in a stepwise manner beginning at the C-terminus with the *p*-(*p*′-methoxy-phenylazo)-benzyloxy carbonyl group (MZ group), described by one of us[3], used as the amino-protecting agent. In addition, the *p*-toluenesulphonyl (tosyl) group was introduced to protect the guanidino group of arginine, since this protecting group resists catalytic hydrogenation and is easily removed by sodium in liquid ammonia. When the peptide was assayed either in the hypophysectomized frog or on frog skin *in vitro*, it was found to possess melanocyte-stimulating activity.

Cyanomethyl carbobenzoxy L-tryptophanate[4] was condensed with methyl glycinate to give Z.Try-Gly.OCH_3. The dipeptide ester resulting from catalytic hydrogenation in the presence of palladium was condensed with N^{α}-MZ-N^{G}-tosyl-L-arginine [prepared by treating MZ-L-arginine[3] with tosyl chloride, or by tosylating carbobenzoxy-L-arginine, removing the carbobenzoxy group and treating the N^{G}-tosyl arginine ($R_F = 0{\cdot}36$ in system A) with MZ-chloride; the product, N^{α}-MZ-N^{G}-tosyl-L-arginine: m.p. 115° C.; $[\alpha]_D = +6{\cdot}1$, 1 per cent in CH_3COOH; $R_F^A = 0{\cdot}61$ (system A), $0{\cdot}38$ (system B)] by means of reaction with dicyclohexyl carbodiimide (DCCI)[5], to give the amorphous MZ.Arg(N^{G}-tos)-Try-Gly-OCH_3, the R_F^A of which equals $0{\cdot}70$ in system A, $0{\cdot}26$ in system B, and $0{\cdot}63$ in system C. (R_F^A designates R_F values on the fully acetylated paper of Schleicher and Schuell. System A is n-BuOH/CH_3COOH/H_2O, 4 : 1 : 1; B is the lower phase of CCl_4/CH_3OH/pyridine/water, 4 : 2 : 1 : 1; C is the upper phase of this system. D is the system n-BuOH/pyridine/CH_3COOH/H_2O, 30 : 20 : 6 : 24; R_F values were obtained with Whatman No. 1 paper.) Catalytic reduction with 10 per cent palladium on charcoal in neutral solution released colourless H.Arg(N^{G}-tos)-Try-Gly-OCH_3, $R_F^A = 0{\cdot}76$ in system A and $0{\cdot}89$ in system D, which gave a positive reaction with ninhydrin and the Ehrlich reagent. This compound was combined with MZ-L-phenylalanine[3] by means of reaction with DCCI, and the product was purified in a column of acetylated cellulose (system C). MZ.Phe-Arg(N^{G}-tos)-Try-Gly.OCH_3 was obtained in crystalline form: m.p. 130° C., $[\alpha]_D = -9{\cdot}0°$, 1 per cent in CH_3COOH, $R_F^A = 0{\cdot}36$ (system C). The absorption spectrum indicates 3 peaks at 290, 350 and 430 mμ with E 9,700, 24,700 and 4,500 respectively (ethanolic solution). H.Phe-Arg(N^{G}-tos)-Try-Gly.OCH_3, obtained by catalytic hydrogenation as a colourless glassy product ($R_F = 0{\cdot}84$, system A), was further condensed with N^{α}-MZ-N^{im}-benzyl-L-histidine, giving MZ.His(N^{im}-benzyl)-Phe-Arg(N^{G}-tos)-Try-Gly.OCH_3 in the form of yellow microscopic platelets, m.p. 132° C., $[\alpha]_D - 6{\cdot}0$, 1 per cent in CH_3COOH, $R_F^A = 0{\cdot}19$ (system B); the spectrum shows 3 peaks at 290, 350 and 432 mμ with E 11,700, 31,900 and 1,640 respectively. Hydrogenation over 10 per cent palladium on charcoal and saponification with barium hydroxide yielded H.His(N^{im}-benzyl)-Phe-Arg(N^{G}-tos)-Try-Gly.OH: $R_F = 0{\cdot}68$ (system A) and $0{\cdot}92$ (system D). Treatment of this product in dry liquid ammonia at −30° C. with 20 equivalents of sodium for a short time, conversion of the resulting peptide to dihydrochloride, and extraction into glacial acetic acid gave the dihydrochloride of H.His-Phe-Arg-Try-Gly.OH as a colourless glassy product, $R_{\text{His}} = 1{\cdot}92$ (system A), which gave a positive reaction with ninhydrin and the Pauly, Sakaguchi and Ehrlich reagents; amino-acid analysis of the peptide by the Levy method[6] and by the spectrophotometric procedure of Goodwin and Morton[7] gave the molar ratio: His/Phe/Arg/Try/Gly = $0{\cdot}9/1{\cdot}1/1{\cdot}1/1{\cdot}0/1{\cdot}0$. The product was completely split by trypsin at pH 7 to give H-His-Phe-Arg-OH ($R_F = 0{\cdot}11$, system A) and H-Try-Gly-OH ($R_F = 0{\cdot}42$, system A); reaction with chymotrypsin at pH 9 resulted in total cleavage of the peptide to H.His-Phe.OH, ($R_F = 0{\cdot}11$, system A), H.Arg-Try.OH ($R_F = 0{\cdot}16$, system A) and glycine ($R_F = 0{\cdot}23$, system A).

The synthetic pentapeptide, when assayed for melanocyte-stimulating activity both on isolated frog skin[8] and in hypophysectomized *Rana pipiens*, was found to possess an activity of 3 × 10^4 MSH units per gm. A hexapeptide, H-Glu-His-Phe-Arg-Try-Gly.-OH, synthesized by H. Kappeler in the laboratory of one of us (R. S.) at Basle by conventional coupling of Glu, His-Phe-Arg, and Try-Gly, has been assayed for MSH activity and found to be more active (2 × 10^5 units per gm.) than the pentapeptide herein reported. It is of interest to note that Hofmann *et al.*[9] reported the synthesis of an octapeptide, H.Ser-Met-Glu(NH_2)-His-Phe-Arg-Try-Gly.OH, with an MSH activity of 7 × 10^5 units per gm. When solutions of the synthetic product (1 mgm./ml.) in $0{\cdot}1$ M sodium hydroxide were kept at 100° C. for 15 min., the resulting products exhibited the characteristic 'prolongation' activity in hypophysectomized frogs found in MSH and ACTH preparations[2] that have been treated in a similar manner. Analysis by the Levy procedure[6] of the pentapeptide after alkali-heat treatment showed that the arginine residue has been partially converted into ornithine. (Earlier preliminary studies with I. I. Geschwind using MSH, ACTH and crude peptide preparations gave similar conclusions.) Whether or not the 'prolongation' effect is due solely to the modification of arginine in the peptide remains to be investigated. Further studies of these problems are in progress.

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Determination of Indole Acetic Acid by the Salkowsky Reaction

RECENTLY attention has been focused on the reaction of indole acetic acid with ferric ions. Cohen *et al.*[1] have shown that indole acetic acid forms a chelate with iron at acid pH and this has been confirmed by Recaldin and Heath[2]. The latter state that at pH $2{\cdot}6$ iron slowly decomposes the indole acetic acid in the solution. The oxidation of indole acetic acid by ferric salts is the basis of the colorimetric determination of the acid based on the Salkowsky reaction[3–5]. It is generally supposed that these reactions measure the formation of a coloured oxidation compound of indole acetic acid formed at very acid pH in the presence of ferric chloride.

Chance observation in this laboratory (by Blumenthal-Goldschmidt) showed that the usual Tang–Bonner reagent gives a different and stronger colour

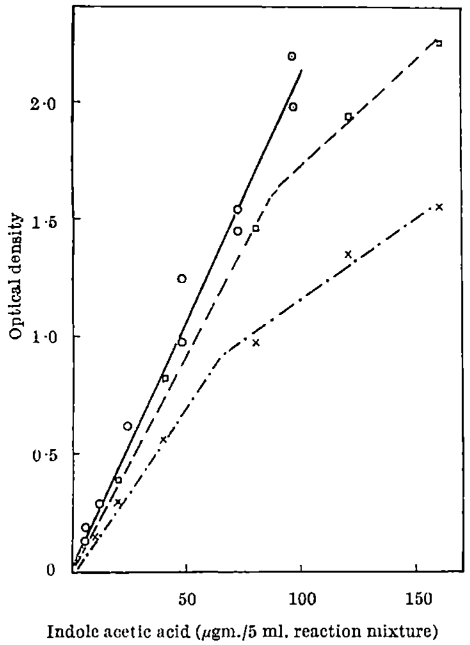

Fig. 1. Relation between concentration of indole acetic acid and intensity of colour as produced by various reactions. ×—×, Tang–Bonner reagent, optical density at 530 mµ; □—□, reagent prepared with trichloroacetic acid, optical density at 545 mµ; ⊙—⊙, reaction for ferrous iron produced by oxidation of indole acetic acid, optical density at 730 mµ

with indole acetic acid in the presence of trichloroacetic acid. This reaction has been investigated in greater detail. It was found that a reagent for indole acetic acid could be prepared in 5·6 *N* trichloroacetic acid containing 30 ml. of 0·5 *N* ferric chloride per 800 ml. trichloroacetic acid, which gives a stronger stable colour with indole acetic acid under the same conditions as the Tang-Bonner reagent[4]. The absorption maximum of this compound was slightly different from that of the Tang–Bonner reagent, namely, at 545 mµ. A comparison of the two reactions is shown in Fig. 1. The trichloroacetic acid reagent shows the same break in linearity of relation between concentration and colour as does the Tang–Bonner reagent[4] and that of Gordon and Weber[5].

It seemed of interest to determine the fate of the iron during the Tang-Bonner reaction. Possibly ferric iron is quantitatively reduced to ferrous iron. 1 ml. of Tang–Bonner reagent was added to suitable samples of indole acetic acid in 1 ml. water and the reaction mixture allowed to stand for half an hour at room temperature. At the end of this period 6 ml. of 0·2 per cent potassium ferricyanide (freshly prepared in boiled distilled water) was added and the mixture was allowed to stand for a further half-hour. The intensity of the bluish-green colour of Turnbull's blue was measured at 730 mµ. As will be seen from Fig. 1, a straight-line relationship exists between the intensity of the colour and the concentration of indole acetic acid in the reaction mixture. The breaks occurring with the other reactions do not appear.

It seems clear that, under the conditions used, indole acetic acid reduces ferric iron quantitatively to the ferrous state. The breaks in the curves with the Tang–Bonner and similar reagents must be due to changes occurring in the oxidation product of indole acetic acid. The estimation of ferrous iron formed due to the interaction of ferric iron with indole acetic acid could form the basis of a quantitative determination of the latter.

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The Spontaneous Change of Ferriprotoporphyrin in Alkaline Solution

THERE are repeated suggestions in the literature that ferriprotoporphyrin in alkaline solution is unstable. Haurowitz[1] observed a decreased diffusion rate with time, and Shack and Clark[2] noted changes in the visible spectrum. Both these observations were interpreted as resulting from an increase in particle size. Rosenfeld and Surgenor[3] found that ferriprotoporphyrin could be separated from the alkaline conversion product by differences in solubility in the two-phase system, *n*-butanol and *p*H 9·6 bicarbonate buffer. In spite of these and other observations, the nature of the reaction remains unknown. In this communication we present spectrophotometric evidence that a chemical change occurs in ferriprotoporphyrin on standing in an aerated alkaline solution, and that the change is probably a modification of the vinyl side-chains.

We have found that in the presence of air and in 0·1 *N* sodium hydroxide the Soret peak of a 10^{-5} *M* solution of ferriprotoporphyrin decreases about 30 per cent in 20 days and then very little more with additional time. This coincides with the change in the visible absorption spectrum observed by Shack and Clark[2]. The rate of the reaction is affected by the concentration of sodium hydroxide. For a 10^{-5} *M* solution of ferriprotoporphyrin the decrease in the Soret peak in 12 days was about 29 per cent for 0·1 *N* sodium hydroxide, 13 per cent for 0·01 *N*, and 6 per cent for 0·001 *N*. Substances which coordinate with iron also reduce the rate of the reaction (Table 1). The rate is very greatly decreased when the iron is complexed with cyanide or pyridine as it is in 0·5 *M* potassium cyanide and 1·2 *M* pyridine[4].

The alkaline conversion product was prepared by storing ferriprotoporphyrin in 0·1 *N* sodium hydroxide for at least three weeks. The *p*H was reduced to 9·6 with carbon dioxide, and unchanged ferriprotoporphyrin was extracted with butanol[3]. The pigment was precipitated from the buffer solution with acid and thoroughly washed with water, alcohol and ether.

To show that the iron atom had not been altered in some way during the reaction it was removed by

Table 1. EFFECT OF ADDITIVES ON SPONTANEOUS CHANGE OF 10^{-5} *M* FERRIPROTOPORPHYRIN IN 0·1 *N* SODIUM HYDROXIDE

Final concentration (*M*)	Additive	Per cent decrease Soret peak at 13 days
	None	26
10^{-4}	Sodium chloride	25
10^{-4}	8-Hydroxy quinoline	16
10^{-4}	Sodium diethyldithiocarbamate	5
10^{-4}	Potassium cyanide	12
0·5	,, ,,	2
1·2	Pyridine	2

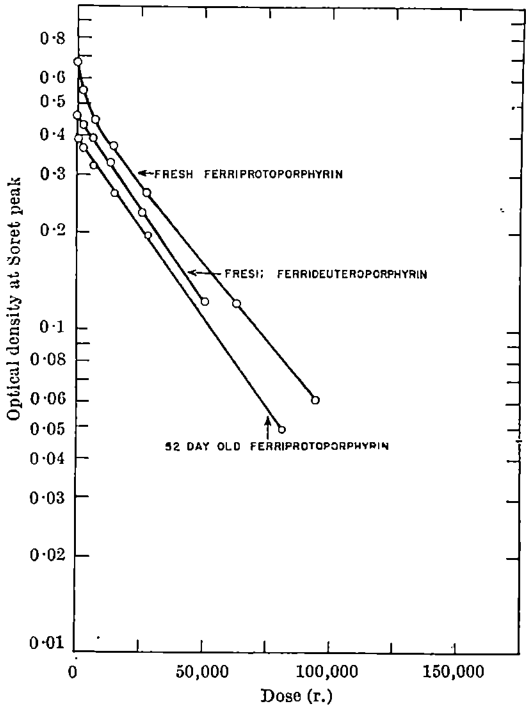

Fig. 1. Gamma irradiation of ferriprotoporphyrin

the method of Morell and Stewart[5]. The resulting porphyrin had absorption maxima in glacial acetic acid 4 mμ toward shorter wave-lengths than protoporphyrin. The porphyrin also differed from protoporphyrin in that most of the pigment precipitated from an ether–acetic acid solution when the acetic acid was extracted.

This slight shift toward shorter wave-lengths also occurs in the spectra of the reduced cyanide and pyridine derivatives of the alkaline conversion product. The maxima in 25 per cent aqueous pyridine and dithionite are at 522 and 552 mμ and in 0·5 *M* potassium cyanide, 0·1 *N* sodium hydroxide and dithionite at 536 and 564 mμ. The corresponding ferriprotoporphyrin derivatives are at 525 and 556 mμ and at 538 and 568 mμ, respectively. Since the position of the visible absorption peaks of such derivatives of ferroporphyrins has been deduced by Drabkin[6] to be attributable to the nature of the side-chains in the 2 and 4 position, the spectral data then suggest that the vinyl groups have been altered.

Further evidence that the vinyl side-chains are involved can be found by comparing the 'ageing' reaction with the irradiation reaction[7]. The change in the visible absorption spectrum of ferriprotoporphyrin in 0·1 *N* sodium hydroxide after standing 20 days is very similar to the change after exposure to 15,000 r. of gamma radiation. The absorption peaks of the alkaline conversion product in 25 per cent pyridine and dithionite are also at almost the same wave-lengths as those of the pigment from irradiated ferriprotoporphyrin in the same solvent. If the reaction in alkaline solution with time is the same as that resulting from 15,000 r., then irradiation of an 'old' solution of ferriprotoporphyrin in 0·1 *N* sodium hydroxide should result only in the second phase of the irradiation reaction. Fig. 1 shows the decrease of the Soret peak with increasing doses of gamma radiation for a sample of a freshly prepared solution of ferriprotoporphyrin in 0·1 *N* sodium hydroxide and for a 52-day-old sample of the same solution. The decrease is exponential throughout for the old solution, and the rate is about the same as that of the exponential decrease of the fresh solution. Also shown in Fig. 1 is the decrease in the Soret peak of ferrideuteroporphyrin in 0·1 *N* sodium hydroxide. Here, too, the rate of decrease is exponential. Furthermore, unlike ferriprotoporphyrin, the absorption spectrum does not change when ferrideuteroporphyrin in 0·1 *N* sodium hydroxide is kept for 6 months. From this, and the evidence in Table 1, it clearly follows then that the vinyl side-chains as well as an uncomplexed central iron atom are necessary for the reaction. The iron apparently is involved in an intermediate step, whereas the observed chemical change seems to be due to an alteration of the vinyl side-chains. No evidence has been obtained as yet concerning the molecular weight of the alkaline conversion product. Polymerization of various vinyl compounds is well known[8] and this would be consistent with the observation of Haurowitz[1].

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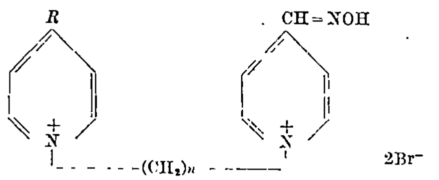
Protection by Oximes of *bis*-Pyridinium Ions against Lethal Di*iso*propyl Phosphonofluoridate Poisoning

THE monoximes and dioximes of *bis*-pyridinium ions are considerably more effective than any other known compound in re-activating acetocholinesterase inhibited by tetraethyl pyrophosphate and in protecting mice against lethal tetraethyl pyrophosphate poisoning[1]. Equally favourable results have now been obtained in experiments in which di*iso*propyl phosphonofluoridate was used instead of tetraethyl pyrophosphate. Tables 1 and 2 show the effectiveness (relative to pyridine-2-aldoxime methiodide) of four oximes of *bis*-pyridinium ions in restoring the activity of acetocholinesterase freshly inhibited by di*iso*propyl phosphonofluoridate, and the protection given by 0·095 m.mole/kgm. of the same compounds against lethal poisoning by di*iso*propyl phosphonofluoridate in mice. Results obtained with three other compounds, a monoxime ($n = 5$) and two dioximes ($n = 2$ and 5), are not included in Tables 1 and 2 because they are inferior to compounds 1–4 as regards therapeutic ratio or water solubility.

Table 1



Compound			Potency as reactivator relative to pyridine-2-aldoxime methiodide (*P*–2–*AM*)
Code number	*R*	*n*	
1	H	3	11
2	H	4	10
3	CH=NOH	3	52
4	CH=NOH	4	38
P–2–*AM*	—	—	1

The method used to determine the potency of the oximes as reactivators was the same as that used previously (ref. 1).

Table 2. PROTECTION AGAINST LETHAL POISONING BY DI*iso*PROPYL PHOSPHONOFLUORIDATE

Male white mice weighing between 18 and 20 gm. were injected intraperitoneally with 0·2 ml. of the oxime in 0·9 per cent sodium chloride solution and then 5–8 min. later they were injected subcutaneously with 0·2 ml. di*iso*propyl phosphonofluoridate in 0·9 per cent sodium choride solution. 0·095 m.mole/kgm. of the oximes, that is, 25 mgm./kgm. in the case of pyridine-2-aldoxime methiodide, were used and mice injected with the oximes alone showed no symptoms

Compound	No. of mice surviving for 24 hr./No. of mice injected					
	mgm. Di*iso*propyl phosphonofluoridate injected per mouse					
	0·1	0·15	0·2	0·4	0·8	1·6
—	6/6	2/6	0/6			
1			6/6	6/6	2/6	0/6
2			6/6	4/6	0/6	
3			6/6	6/6	3/6	0/6
4			6/6	5/6	1/6	0/6
P–2–*AM*		6/6	2/6	0/6	0/6	

A more detailed study of the antidotal properties of compounds 1 and 3 in mice showed that they raised the *LD*50 of di*iso*propyl phosphonofluoridate 1–2 and 2–3 fold respectively when used in a dose of 0·0095 m.mole/kgm. under conditions described in Table 2. The effect of the two oximes was potentiated by 1 mgm./kgm. atropine sulphate (given intraperitoneally 15 min. before the oxime). Such a dose of atropine had no antidotal effect itself but, when used in conjunction with 0·0095 m.mole/kgm. of compounds 1 and 3, raised the *LD*50 of di*iso*propyl phosphonofluoridate by 2–3 and 5–7 fold respectively.

Partial reactivation of di*iso*propyl phosphorylacetocholinesterase in blood but not in brain was recorded in mice which received a subcutaneous injection of 2·5 mgm./kgm. di*iso*propyl phosphonofluoridate, followed 30 min. later by an injection of 0·095 m.mole/kgm. of compound 3. These findings show that the oximes of *bis*-pyridinium ions act predominantly peripherally and that the mechanism responsible for their antidotal action involves reactivation of the phosphorylated acetocholinesterase.

It has previously been shown that the di*iso*propyl phosphorylacetocholinesterase formed initially has an approximate half-life of 4 hr. and changes into a phosphorylated enzyme which cannot be reactivated by pyridine-2-aldoxime methiodide[2]. The oximes of *bis*-pyridinium ions also fail to restore the activity of the phosphorylated enzyme resistant to pyridine-2-aldoxime methiodide, and thus marked therapeutic effects of compounds 1–4 will only be obtained when they are administered within a few hours following exposure to di*iso*propyl phosphonofluoridate. Keeping this limitation in mind, it seems that the results obtained raise the hope that a really effective causative treatment of poisoning of man by tetraethyl pyrophosphate, di*iso*propyl phosphonofluoridate and related organophosphates might soon become available.

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Myasthenic-like Features of Neuromuscular Transmission after Administration of an Inhibitor of Acetylcholine Synthesis

IT has been suggested that a defect of acetylcholine synthesis in motor nerve endings would account best for the peculiar features of neuromuscular block seen in myasthenic patients[1]. This hypothesis can be tested by investigating the effect on the skeletal muscle of the cat of a recently developed drug[2], hemicholinium base *HC*3, which strongly inhibits the synthesis of acetylcholine by nervous tissue[3].

Fig. 1 presents typical observations from a myasthenic patient free from any drug (*B*), a cat treated with hemicholinium *HC*3 (*C*), and another cat mildly paralysed with *d*-tubocurarine (*D*). What is being compared is the pattern of changes in neuromuscular block following a brief faradization of the motor nerve. The amount of block is estimated by delivering supramaximal shocks at 3/sec. to the motor nerve and recording the integrated electrical response of the muscle with belly-tendon electrodes. The responses at 3/sec. exhibit a typical decrement in partially curarized muscle[4], in myasthenic muscle[5,6] and also in muscle treated with hemicholinium. I find that the percentage reduction of, say, the fifth response of the 3/sec. train with respect to the first response (*b* : *a*, in Fig. 1,*A*) is a very sensitive and reliable test of synaptic failure in the three conditions which are being compared.

The post-tetanic effects shown in Fig. 1,*B* are similar to those previously described for another myasthenic[6] and they are typical of the syndrome. In the 3/sec. test-trains elicited every minute or so, the fifth potential is about 66 per cent of the first in this case (see diagram). After faradization, a short-lived facilitation appears, followed by a prominent phase of post-tetanic exhaustion (3 min. after tetanus, fifth potential in the test-train is 29 per cent of first) which is dissipated in the following 15–20 min. This enduring increase in neuromuscular block is obviously the analogue of the long-lasting component of the pathological fatigue seen clinically in these patients[6].

The neuromuscular defect produced by hemicholinium *HC*3 in cat's muscle is peculiar: intravenous injection of the drug does not produce any failure of the indirect response until after the motor nerve has been repeatedly stimulated and the stocks of preformed transmitter have thereby presumably

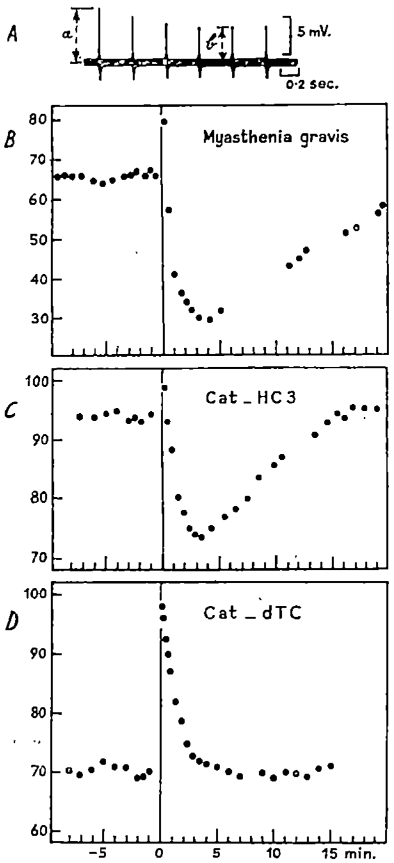

Fig. 1. In each diagram the abscissa represents time in minutes following (or preceding) faradization of motor nerve. The ordinate represents the percentage reduction of the voltage of the fifth response in a 3/sec. test-train with respect to the voltage of the first response in same train; this percentage decrement is proportional to the amount of neuromuscular block. The procedure used to estimate the decrement is illustrated on an actual record from myasthenic muscle in *A*.

B, Myasthenic patient never treated with drugs up to the time of the experiment. Results from adductor pollicis muscle stimulated supramaximally through ulnar nerve. Intramuscular temperature, 36·3° C. At zero time the ulnar nerve is faradized at 50/sec. for 2 sec.

C, Cat, 3 kgm., anæsthetized with chloralose. Hemicholinium base *HC*3 injected intravenously 1 hr. before (1·5 mgm./kgm.). Results from tibialis anticus muscle stimulated supramaximally through peroneal nerve. Intramuscular temperature, 33·2° C. Rectal temperature, 37° C. At zero time the nerve is faradized at 50/sec. for 10 sec.

D, Cat, 2·2 kgm., anæsthetized with chloralose. A constant intravenous infusion of *d*-tubocurarine ('Intocostrin', Squibb) maintains a steady state of partial curarization. Data from tibialis anticus muscle stimulated supramaximally through peroneal nerve. Intramuscular temperature, 34° C. Rectal temperature, 36·2° C. At zero time the nerve is faradized at 50/sec. for 3 sec.

been depleted. In the experiment illustrated (Fig. 1,*C*) about 5,000 shocks had been delivered to the motor nerve during the hour following injection of 1·5 mgm./kgm. hemicholinium *HC*3. At the beginning of the diagram, a small decrement is seen in the 3/sec. test-train, the fifth response being 93 per cent of the first. After faradization, a short-lived facilitation appears, followed by a considerable deepening in the neuromuscular block (3 min. after tetanus, the fifth response in the test-train is only 73 per cent of first). This 'post-tetanic exhaustion' is dissipated in about 15 min.

In contrast with the above, the muscle partially paralysed with *d*-tubocurarine (Fig. 1,*D*) does not show any increase in the amount of block after faradization. There appears only the well-known facilitation of transmission which is dissipated in the 3–5 min. following the 50/sec. tetanus.

The post-tetanic effects recorded in myasthenic patients free from any drug and in the cat's muscle treated with hemicholinium thus appear strikingly similar, and they differ completely from what is observed in partially curarized muscle. It is suggested that the pattern of these effects results from the interaction of two opposing processes with different time-courses: (*a*) facilitated ejection of acetylcholine from nerve endings which lasts about 4 min. after a 50/sec. tetanus, and (*b*) depletion of stocks of preformed acetylcholine in nerve endings. In normal or curarized muscles, synthesis of transmitter would roughly keep pace with ejection provided physiological rates of stimulation (less than 50/sec.) are used. By contrast, in myasthenic muscles or in muscles treated with hemicholinium, such quick restoration could not occur, and the facilitation of the release of acetylcholine would only transiently mask the depletion (see ref. 1).

The evidence presented strongly supports the suggestion that the myasthenic condition results from a presynaptic biochemical defect chronically impairing synthesis of acetylcholine. However, the experiments do not indicate which step in the process may be disorganized (such as cholinacetylase deficiency, impaired choline transport, etc.). Finally, it is thought that a lasting alteration in presynaptic function might induce secondary changes in motor end-plate behaviour, which would account for the changed reaction to drugs described by others[7].

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Effect of Adrenaline on Neurofibril Formation in Adult Mammalian Cortical Neurones in Tissue Culture

In recent experiments, the addition of adrenaline (0·001–0·005 μgm./ml.) to *in vitro* cultures or subcultures of adult mammalian cerebral cortex invariably caused the appearance of neurofibrils in the neurones within 30–90 min. The formation of neurofibrils was recorded, with phase-contrast time-lapse photomicrography, on the living neurones.

The occurrence of neurofibrils in tissue cultures has been described by Levi and Meyer[1] and Weiss and Wang[2] in ganglion cells of chick embryos. They could be seen with greater frequency in fixed and stained preparations than in living cells. Similar observations were made by R. S. Geiger[3] on cultures and subcultures of adult mammalian cerebral and cerebellar cortex.

Almost immediately after the addition of adrenaline to the cultures, the optical density of various nucleolar and other nuclear areas started to change. Fibrils

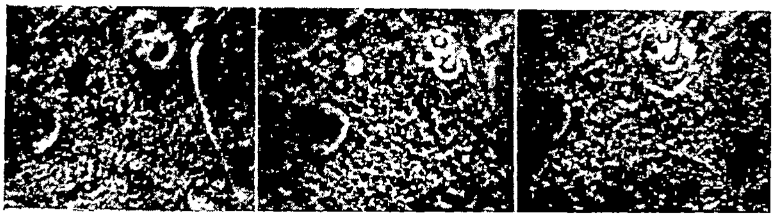
(a) (b) (c)

Fig. 1. Single frames from time-lapse ciné film, ×133 phase-contrast of cell body of a large pyramidal neurone from the cerebral cortex of adult rabbit, second subculture, 68 days in culture. (a) 60 min. after addition of 0·001 μgm./ml. adrenaline; (b) 90 min. after addition; (c) 120 min. after addition

appeared first at the nucleoli, often as a beaded chain, and from there extended gradually into the nucleoplasm and cytoplasm. They wound first around the nucleus, then spread into the remainder of the cytoplasm, the dendrites and axon. They gradually became thicker, and in large neurones often appeared as tangles of thread. Cytoplasmic granules usually surrounding the nuclear boundary dispersed irregularly. About one hour after the addition of adrenaline many large aggregates of granules were seen in the cytoplasm and dendrites.

The nucleoplasm condensed towards the nucleoli, often surrounding them with a ring consisting of material of high optical density. Both nuclei and nucleoli showed patches of varying densities, some areas appearing completely clear. The neurofibrils always appeared first at the nucleolus. The areas from which the fibrils originate are strongly osmophilic and they increase in size as fibril formation proceeds (Figs. 1 and 2).

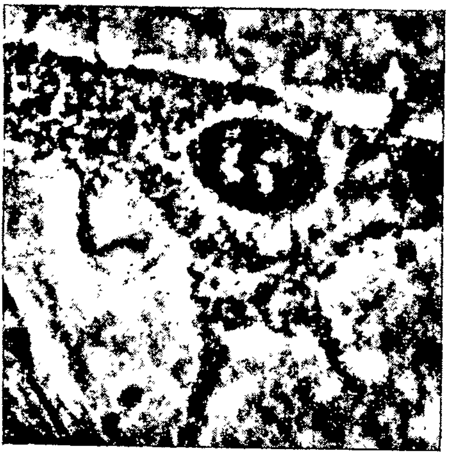
Fig. 2. Neurone from second subculture cerebral cortex of adult rabbit, 72 days in culture, exposed to 2 per cent osmic acid vapour for 30 min., 60 min. after addition of adrenaline, 0·001 μgm./ml.

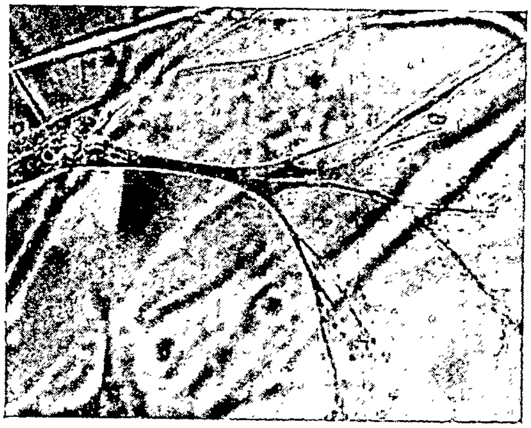
Fig. 3. Neurone from second subculture cerebral cortex of adult rabbit 20 hr. after addition of adrenaline, 0·001 μgm./ml. (× 125) photographed with ordinary light

One to two days after addition of adrenaline, even if neurofibril formation is still progressing, the nucleus assumes a more normal or resting appearance, the nucleoplasm as a whole appears more uniform, as does the nucleolus, which becomes smaller (Fig. 3.)

The osmophilic areas of the nucleoli also take up janus green *B* (conc. 1 : 150,000) and this janus green *B* staining material is associated with the newly formed fibrils in the nucleus. Janus green *B*, although toxic to neurones, causing chromatolysis and degeneration often within 24 hr., did not inhibit neurofibril formation in the cultures treated with adrenaline. The findings of Allfrey and Mirsky[4] that janus green *B* does not inhibit synthesis of adenosine triphosphate by isolated thymus nuclei, although it inhibits it in mitochondria, may be relevant here.

In the cytoplasm of neurones vitally stained with janus green *B* and neutral red, both the mitochondria and neutral red-staining granules are intermingled with fibrils. However, after chromatolysis sets in, many of the neutral red-staining granules disappear and the mitochondria are seen at the border of the vacuoles, disassociated from the fibrils. The neurofibrils remain visible throughout the neuroplasm, and are separated from other organelles.

I wish to thank N. A. Bartley for assistance in photomicrography, and the Department of Public Welfare of the State of Illinois for its support.

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Plateau Formation and Sulphydryl Groups in the Plasma Membrane

It is well known that there are two types of the action potential. The difference between these is principally due to the degree of plateau formation. The modern sodium theory of Hodgkin and Huxley describes faithfully the initial phase of action potential, but the interpretation of the recovery phase in terms of the sodium theory met with many difficulties[1]. To obtain more accurate knowledge of the action potential, we have studied the mechanism of plateau formation.

Experiments were made on myelinated nerve fibres and ventricle muscle fibres of the Japanese toad. To detect the action current of a single isolated nerve fibre, Tasaki's air-gap method[2] was employed. The action potentials of single isolated cardiac muscle fibres were recorded electrically with intracellular micro-electrodes[3].

When the myelinated nerve fibre was treated with various divalent metallic ions or with some oxidizing agents, such as *p*-quinone and hydrogen peroxide, a

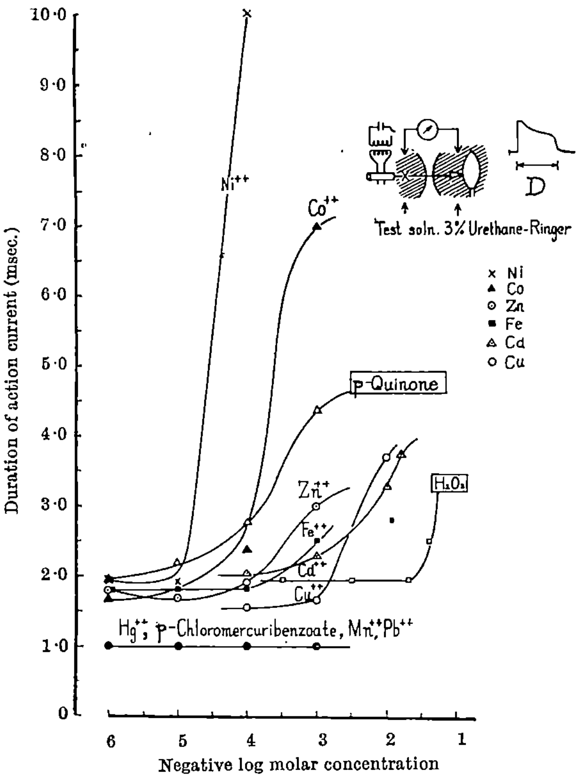

Fig. 1. Plateau-forming action of various agents

marked plateau appeared in its action current. In Fig. 1, the duration of action currents is plotted as a function of the concentration of their effectors.

The plateau formation disappeared completely on the addition of cysteine (Fig. 3,*a*). With this cysteine recovery, the plateau-forming strength of each metallic ion could be compared in the same preparation. Their relative strengths in 10^{-3} *M* were as follows: iron, copper, zinc and cadmium, 0·1–0·2; cobalt, 1·0; nickel, 3·0–4·0.

Within limits, the duration of the plateau was prolonged with increase in the concentration of the agents, but high concentrations of the agents rather tended to curtail the plateau. In Fig. 2 this effect is shown for cobalt as an example. The optimal concentration for plateau formation by cobalt and nickel ions was 10^{-3} *M* (Fig. 3,*b*).

On the other hand, the effect of agents at high concentration was reversed by washing with fresh Ringer or by the addition of cysteine at a relatively low concentration.

p-Chloromercuribenzoic acid ($10^{-6} - 5 \times 10^{-4}$ *M*) did not show any appreciable plateau formation. But it could inhibit strongly the plateau formation of cobalt or nickel ions.

Anoxia and various metabolic inhibitors (fluoride, monoiodoacetate, phlorizin, malonate, cyanide, azide, dinitrophenol, arsenite, arsenate, etc.) did not change the wave configuration of the action current. Consequently, plateau formation in a single nerve fibre is not due to the inhibition of metabolism.

Our findings can be explained by assuming that plateau formation in the action current is due to —S—*Me*—S— linkage (where *Me* is a divalent metal) of sulphydryl groups in the plasma membrane (presumably in the membrane protein) and that Cl—*Me*—S— is inactive in plateau formation.

In the toad's heart muscle, the action potential of which shows a marked plateau, it was reported by Takahashi *et al.*[4] that the plateau was curtailed reversibly by SH-reagents. Fig. 3,*c* shows that curtailment of the plateau can be brought about by cadmium ions without changes in spike height or in resting potential.

These findings suggest that in the cardiac muscle fibre, sulphydryl groups are present mainly in the

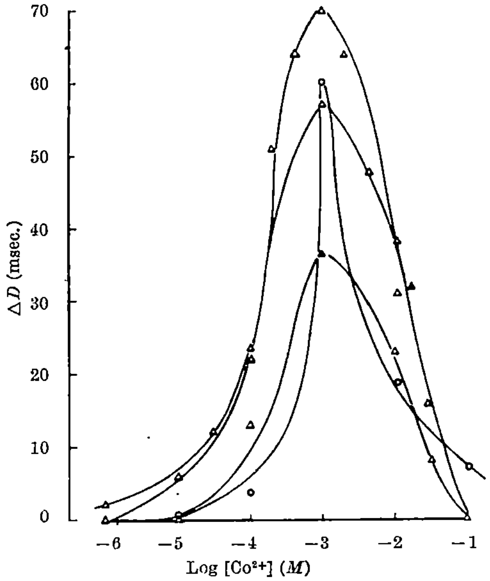

Fig. 2. The relation between the plateau-forming action and concentration of cobalt ions. The ordinate, ΔD, is the duration of action current in presence of cobalt ions minus duration in normal fibres. ○, results with medium free of calcium ions

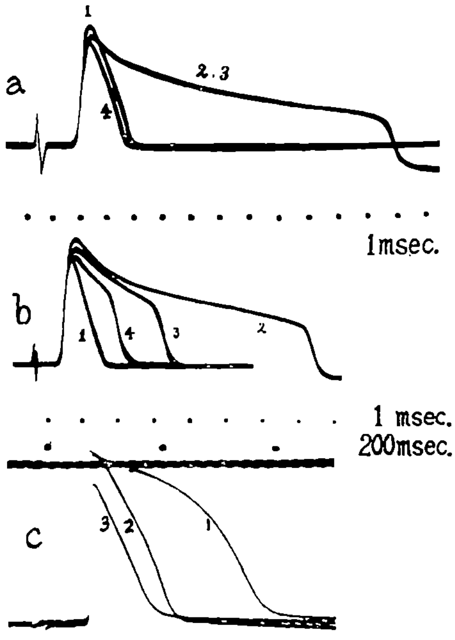

Fig. 3. (*a*) Plateau formation by a nerve fibre treated with CoCl$_2$ at 14·0° C. 1, Control; 2, after CoCl$_2$ (10^{-3} *M*); 3, after washing with Ringer solution; 4, after the addition of cysteine hydrochloride (10^{-3} *M*). (*b*) Plateau formation and CoCl$_2$ concentration in the calcium-free medium (20·0° C.). 1, Control; 2, 3, 4, action currents following the administration of 10^{-3} *M*, 10^{-2} *M* and 10^{-1} *M* CoCl$_2$. (*c*) Action potential of SH-blocked cardiac muscle fibre (25·0° C.). 1, Control; 2, 15 min. after CdCl$_2$ (10^{-3} *M*); 3, 21 min. after CdCl$_2$ (10^{-3} *M*)

oxidized —S—S— form, and that they play an important part in plateau formation.

A fuller account of these experiments will be published elsewhere.

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Incorporation of Manganese into Erythrocytes as Evidence for a Manganese Porphyrin in Man

MANGANESE is established as an essential constituent of the body. Kinetic studies[1] have shown this element to exist predominantly in a labile, easily exchangeable form. Natural organometallic compounds of manganese have not been identified in vertebrates.

Manganese has been assumed to participate indirectly in hæmatopoiesis[2]. Natural porphyrins are known which are bound to metals other than iron[3] (namely, vitamin B_{12} and chlorophyll). Nevertheless, manganese has not been implicated hitherto in the structure of either the erythrocyte or the respiratory pigments. The present results show a firmly bound manganese component in human and rabbit erythrocytes which appears in good yield in the crystallized hæmin fraction, suggesting that it may have a role in the porphyrin metabolism of cells.

Following the injection into patients of carrier-free manganese-54 (half life, 300 days), the kinetics of the initial venous blood clearance were entirely consistent with the patterns previously reported[1] for the short-lived isotope, manganese-56. The use of a single-channel pulse height analyser provided measurements of the venous blood and plasma manganese-54 even after the first several hours, when readings on conventional scintillation counters had fallen to statistically insignificant levels. With this method, the radioactivity in blood was lowest 36–48 hr. after intravenous injection, followed by a rise over the next week or ten days to a plateau value (Fig. 1). Centrifugation of the blood samples showed this biphasic response to represent two separate processes: (*a*) rapid disappearance of radioactivity from plasma and (*b*) slow appearance and retention in circulating erythrocytes (Fig. 1).

Blood taken from a patient 66 days after injection of manganese-54 contained almost the entire radioactivity in the red cell fraction. (There was no selective concentration of manganese-54 in the buffy coat.) Repeated washing with saline failed to elute the isotope, and when the cells were hæmolysed with 7 volumes of distilled water, there was insignificant accumulation of tracer in the packed stroma ('ghosts'). The rigorous dialyses summarized in Table 1 failed to remove any appreciable amount of radioactivity from hæmolysates tested directly, indicating that the metal was non-dialysable, non-exchangeable, and not available for chelation with disodium ethylenediamine tetraacetic acid.

This incorporation of manganese-54 into red cells *in vivo* was quite distinct from the uptake of isotope by the cells *in vitro*. Agitation of blood with carrier-free $^{54}MnCl_2$ at room temperature for 18 hr. showed relatively little binding by erythrocytes, and most of the activity then bound was eluted readily with saline washes. On hæmolysis the tracer concentration in the stroma was 2·5 times higher than that in the hæmolysate, and dialysis was extremely effective in removing manganese-54 from the hæmolysate (Table 1). These experiments indicated that traces of manganese added *in vitro* to mature erythrocytes or their hæmolysates were bound relatively weakly and primarily to the stroma, in contrast to the physiologically deposited manganese, which was incorporated into a structural component of the hæmolysate.

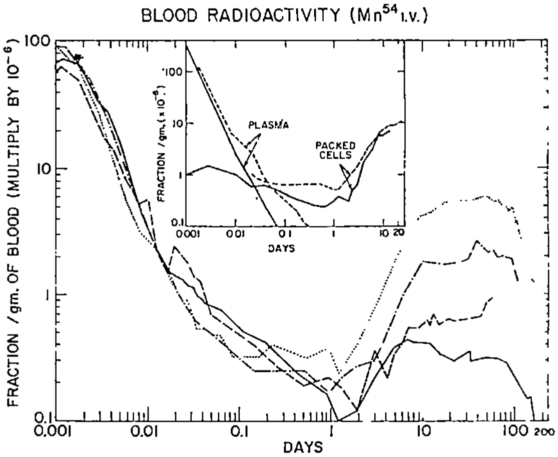

Fig. 1. Time-curves of venous blood radioactivity following intravenous injection of $^{54}MnCl_2$ into several patients. Ordinate values represent the fraction of administered manganese-54 per gm. (of whole blood, plasma, etc.) corrected to 70 kgm. of body-weight. Insert shows detailed behaviour of centrifuged blood fractions in two representative cases, wherein the packed cells have been washed twice in saline

The time-course of the reappearance of manganese-54 in blood (Fig. 1) is similar to that which follows iron-59 injections[4]. It resembles even more closely the time-curve[5] of protoporphyrin labelled with nitrogen-15. Therefore this phenomenon may indicate the synthesis of a manganese porphyrin. Experiments with both human and rabbit blood showed that the incorporated radiomanganese was isolated predominantly in the crystallized hæmin[6]. The high acidity of the media employed for crystallization favoured solubilization of manganese porphyrins and precipitation of iron porphyrin[7]. Even so, successive recrystallizations showed a relatively small

Table 1. DIALYSIS OF HÆMOLYSATE CONTAINING MANGANESE-54 FOLLOWING INJECTION INTO A PATIENT SEVERAL WEEKS EARLIER OR FOLLOWING DIRECT MIXING *in vitro*

Hæmolysate was obtained from the supernatant after washed red cells had been made up with 3 volumes of water and then centrifuged

Dialysate	Duration (hr.)	Manganese-54 injected		Manganese-54 added *in vitro*	
		Measured (c.p.m./sample)	Comparative (per cent)	Measured (c.p.m./sample)	Comparative (per cent)
Before dialysis	—	1,054	100	139,561	100
Running water	9	1,039	99	125,510	90
0·01 *M* $MnCl_2$	29	1,051	100	15,052	11
0·005 *M* EDTA*	17	1,117	100	6,913	5·0
Repeat EDTA	23	1,060	100	2,010	1·4
25 per cent PVP†	23	1,003	95	240	0·2

* Disodium ethylenediamine tetraacetic acid.
† Polyvinyl pyrrolidone.

fall of radioactivity per unit weight of hæmin, indicating that in all probability the manganese organometallic compound under study is indeed a porphyrin. Experiments are now in progress to characterize this manganese-porphyrin complex more precisely.

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Effect of Viral Infection and Cortisone upon Tumour Growth in Homologous and Heterologous Hosts

RECENTLY, human tumours have been successfully transplanted to rats and hamsters conditioned with X-ray and/or cortisone, and several cell lines are now available for use in studying the effects of chemotherapeutic agents or viruses on them[1–4]. Human tumour HeLa cells, grown in tissue culture, have also been transplanted to conditioned rats and their viral susceptibility examined[5]. However, the problem of whether experimental results obtained by using tumours transplanted to a heterologous host, such as a hamster, could be applied directly to cancer in human beings or not remains to be solved. In the present communication, a transplantable mouse tumour is adopted as an experimental model and the interaction of extraneous viruses and tumour in homologous and heterologous hosts is examined, together with the effect of cortisone upon tumours in different host species.

Fructose sarcoma was chiefly used as before[6]. Fragments of the tumour were transplanted into the subcutaneous space of the back of mice and to one or both sides of the breast of rats, using a trochar. Rats, weighing about 80 gm., were treated with 5 mgm. of cortisone just after tumour transplantation and received two to three additional injections of 5 mgm. at four day intervals. Sarcomas in rats treated with cortisone attained the size of 2·0 cm. × 1·5 cm. within ten days. Mice were not treated with cortisone. About a week after tumour transplantation, 10^{-5} dilution of Col-*SK* virus was injected directly into tumours in mice and in rats. On the second and fourth or fifth day after virus inoculation, tumours were extirpated and their *LD*50 measured by intracerebral titration in mice. As shown in Fig. 1*a*, the infectious titre of the virus in tumours grown in rats was always higher than that grown in mouse tumours. In such instances, the growth of virus-infected and control tumours in mice was almost the same, but in rats treated with cortisone there were distinct differences: namely, in rats the sarcoma continued to grow for 3–4 days after virus inoculation and then it began to regress, whereas non-infected tumour did not usually show any sign of regression as long as cortisone treatment was continued. The fact that virus-infected sarcoma does not regress in mice, but does regress in rats, suggests that immunological host factors are operating. In rats without cortisone treatment, the sarcoma often began to regress about 12 days after transplantation. Thus the immunological responses of the host against heterologous tissue may act in addition to the cytopathic effect of virus in causing tumour regression.

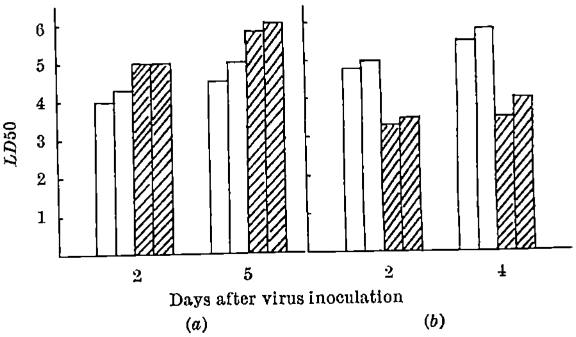

Fig. 1. Propagation of (*a*) Col-*SK* virus and (*b*) *WEE* virus in sarcomas grown in mice and rats. Unshaded, mice; shaded, rats

The same experiments were performed using Western equine encephalomyelitis virus (Fig. 1*b*). Here, the virus titre in tumours grown in rats was lower than in those grown in mice, and tumour development was not impaired in rats as it was in mice, despite virus propagation[7]. Thus, the multiplication of extraneous viruses in tumours grown in homologous and heterologous hosts depends on the host animal. In other experiments, we transplanted Rous sarcoma into chickens and cortisone-treated hamsters, and compared the tumour sizes and virus yields. Though the size of the tumours in hamsters was much smaller than in chickens, virus yield was equal to or greater than from sarcomas in chickens[8]. On the other hand, Chaproniere and Andrewes[9] reported that the myxoma virus of the rabbit multiplies in homografts of tissues from normally resistant species, such as the guinea pig. Changes in the physiological conditions of the cells cause alteration of the cell susceptibility to viruses.

To test the effect of cortisone upon tumour and viral growth in mice, mice were treated with 2·5 mgm. of cortisone at 4-day intervals after tumour grafting. In contrast with grafts in heterologous hosts (rats), the growth of the primary tumour in mice was suppressed by cortisone treatment. Moreover, in mice treated with cortisone, metastases were quite often found in lung and kidney (Fig. 2). Col.-*SK* virus was

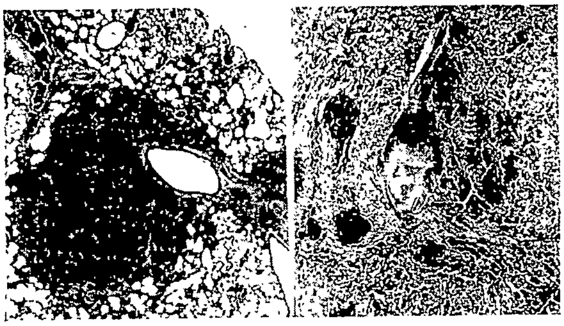
(*a*) (*b*)

Fig. 2. Metastases in (*a*) lung and (*b*) kidney of mice treated with cortisone. (× 11)

injected into tumours in such mice and the *LD*50's of sarcomas in cortisone-treated and non-treated mice were compared. There were no significant differences in the virus titres. Therefore, differences in the virus titres between sarcomas grown in cortisone-treated rats and non-treated mice may not be due to the influences of cortisone but to the effects of the host animal.

Details of these experiments will be published elsewhere.

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A Biological Action of Injected Deoxyribonucleic Acid

It is well known that when body cells are seriously injured, the blood and urine of animals are able to degrade deoxyribonucleic acid, in a way closely resembling the action of deoxyribonucleases I and II. In this communication we therefore refer to these activities as the effect of deoxyribonucleases. Several explanations of this phenomenon are possible. Two of them provided the background for this investigation : (*a*) the enzymes are extruded from damaged cells, (*b*) with the release of the cell contents a reaction is started which ultimately leads to a rise in deoxyribonuclease activity. The facts in favour of this point of view were given by Kowlessar and Altman[1]. They found rising deoxyribonuclease activities following irradiation of the whole body. In rats the maximum activity in the body fluids of deoxyribonuclease II is found on the first, and of deoxyribonuclease I on the sixth day, following exposure to X-rays. This makes it unlikely that one mechanism would be responsible for both maxima.

When cells are destroyed all kinds of substances may enter the body fluid pool ; for example, enzymes and the contents of the cell nucleus with its highly specific genetically active deoxyribonucleic acid. The body would have to neutralize this dangerous material and might bring an adaptive mechanism into action. If this were so, application of deoxyribonucleic acid should provoke a rise of deoxyribonuclease activity in the body.

We injected a solution of 0·2 per cent deoxyribonucleic acid in 0·85 per cent saline, *p*H 7·4, into the ear vein of rabbits ; the deoxyribonucleic acid was prepared from *Holothuria polii* sperm[2]. The injections were given during the course of a week, and a total of 78 mgm./kgm. was administered per rabbit. At zero time, after 1 day, 2 days and 5 days, blood samples were taken. The clotted blood was spun down at 5,000*g* (20 min.). 0·5 ml. of the serum, 0·5 ml. of a 0·01-*M* magnesium sulphate solution and 4·0 ml. of a 0·5 per cent deoxyribonucleic acid solution, all of *p*H 7·4–7·6, were brought to 25° C. and the viscosities were measured in an Ostwald-type viscometer with a water outflow time of 22·0 sec.

Table 1. Viscosimetric Determinations of Deoxyribonuclease Activities following Deoxyribonucleic Acid Injections

Incubation time (hr.)	Viscosity change in per cent (zero time viscosity 100)			
	No injection	1 day after first injection	2 days after first injection	7 days after first injection
0	±0·0	±0·0	±0·0	±0·0
0·5	+11·4±1·4	+2·4±0·8	+4·8±0·7	−1·1±0·3
1·0	+12·7±1·1	+3·4±0·8	+3·3±0·7	−3·6±0·6
1·5		+4·2±0·8	+3·8±0·7	−4·6±0·6
2·0		+4·9±0·7	+3·7±0·7	−3·7±0·6
15·5	+14·6±1·1			
17·0				−7·8±0·6
17·5			−5·1±1·0	
18·5			−5·3±0·5	−8·0±0·6
19·0		±0·0±0·6		
19·5	+13·8±1·1			
22·5	+12·3±0·9			

Total : 630 measurements

The increments in viscosity and the incubation times are given in Table 1. Upon mixing deoxyribonucleic acid with zero-time serum there is an initial rise in viscosity. During the following 24 hr. the viscosity drops somewhat. In the sera withdrawn after injection the behaviour is different. In the initial phase the rise in viscosity is not very great, or is even negative, and during the next 24 hr. viscosity decreases considerably.

In the rabbit the natural deoxyribonuclease activities are quite low, but they are higher in the rat. It was therefore of interest to determine whether there is any deoxyribonuclease activation at all, since it is conceivable that the deoxyribonucleic acid molecule would be broken down by the high 'natural' deoxyribonuclease activity before it could develop its deoxyribonuclease-provoking effect.

Yet in the rat it was impossible to inject deoxyribonucleic acid solutions of as high a viscosity as was possible in the rabbit. It was therefore given intraperitoneally in doses of 500 mgm./kgm. This higher dose was thought necessary because of the different mode of application. For deoxyribonuclease determinations we used the method of Allfrey and Mirsky[3]. The acid and the neutral deoxyribonuclease were run in parallel. Five rats were killed one day after deoxyribonucleic acid application and another five one week later. A third set of untreated animals served as controls. The clear supernatant serum was used to act upon deoxyribonucleic acid for 0, 1 and 24 hr. at *p*H 5·2 and 7·4. Trichloracetic acid was then added and the solution centrifuged at 5,000*g* for

Table 2. Determination of Deoxyribonuclease Activities by the Method of Allfrey and Mirsky (ref. 3)

Time of incubation of samples (hr.)		Animals injected with saline		Animals injected with deoxyribonucleic acid solution	
		Deoxyribonuclease I	Deoxyribonuclease II	Deoxyribonuclease I	Deoxyribonuclease II
Rats	0	100	100	100	100
	1	112±19	123±20	358± 43	250±24
	24	110±18	191±26	540± 75	585±47
Rabbits	0	100	100	100	100
	1	100±65	100±50	1,280±260	905±60
	24	165±65	175±25	3,050±150	1,430±20

20 min. The clear supernatants served as substrate in the Dische reaction. In Table 2 the figures are given in percentage, zero time averages taken as 100.

The principal result of both series of investigations is the same. Injection of deoxyribonucleic acid provokes a sharp and highly significant rise in deoxyribonuclease activity. Apparently both deoxyribonucleases, acid and neutral, are activated. We believe that this behaviour might help in developing a biological test for deoxyribonucleic acid. We are aware of several further implications and investigations will be continued. A full account of the preliminary experiments will be given elsewhere.

We wish to thank the Deutsche Forschungsgemeinschaft for financial support. We are especially grateful to Dr. C. Vendrely and Dr. R. Vendrely from the Centre de Recherches sur les Macromolécules in Strasbourg, who, in a recent letter to us, stated that they had verified parts of our experiments.

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Serological Detection of Fermentation Wastes

Waterborne wastes from the fermentation industries are difficult to differentiate from natural biological metabolites that occur in streams. Detection of characteristic antigens from organisms would serve to identify such wastes as contributors to the pollution of streams. A study was undertaken to determine if sufficient antigenic material for detection was produced in the medium during fermentation and if the antigens were sufficiently stable to permit recovery and identification in microgram amounts.

Three unrelated organisms, *Penicillium chrysogenum*, *Streptomyces lavendulae* and *Escherichia coli*, were grown in a non-antigenic medium consisting of glucose and inorganic salts using a fermentor stand variable drive assembly (New Brunswick Scientific Co., New Brunswick, New Jersey). The cultures were harvested during the vigorous growth stage when autolysis was at a minimum. The cells were removed from the broth with a millipore filter and filtrates autoclaved at 15 lb./in.^{2} for 15 min. The heated filtrates were vacuum concentrated at 56° C., dialysed against distilled water, and reconcentrated to a small volume. The concentrates were made isotonic before injecting into rabbits. Each animal received sixteen injections over a four-week period. While the concentrates from the *Penicillium* and *Streptomyces* were well tolerated, the *E. coli* concentrate was very toxic.

The antisera obtained from the rabbits seven days after the last injection were tested against their homologous antigens by the tube precipitin test. The concentrated filtrate from the submerged fermentation of *P. chrysogenum* failed to elicit any antibody response. Serum from rabbits receiving the *S. lavendulae* concentrate had a titre of 20 μgm. of antigen nitrogen/ml. The antiserum against *E. coli* concentrate had a titre of 1·25 μgm. nitrogen/ml.

The concentrates from *P. chrysogenum* and *S. lavendulae* were incorporated into Freund adjuvant ('Bacto-Adjuvant', Complete (Freund), Difco Laboratories) and injected into rabbits. The *Penicillium* antiserum, prepared this way, was precipitated with its homologous antigen at a dilution of 20 μgm. nitrogen/ml. The *Streptomyces* antiserum was capable of detecting 1·25 μgm. of nitrogen in the filtrate. Neither of these antisera cross-reacted with the opposite concentrate or the *E. coli* concentrate. No additional specificity reactions have been examined.

Antisera were also prepared against unheated saline-washed *P. chrysogenum*, *S. lavendulae* and *E. coli* whole cells. The *Penicillium* and *Streptomyces* mycelial antisera gave a precipitate with their homologous mycelia-free filtrates at a dilution containing 1·25 μgm. nitrogen/ml. The antiserum to the *E. coli* whole cells had an agglutination titre of 1 : 5,120 and gave a precipitate with 1·25 μgm. of filtrate nitrogen/ml.

The concentrates were studied by a slightly modified Ouchterlony[1] plate gel diffusion technique. There was a minimum of three antigens in the *E. coli* and *Penicillium* concentrate and at least five in the *Streptomyces* concentrate. The *E. coli* cell antiserum and the *E. coli* concentrate antiserum gave comparable patterns by the gel diffusion method when run against the *E. coli* concentrate.

The three concentrates were further purified by ethyl alcohol (70 per cent v/v) precipitation. The purified antigens from *Penicillium*, *E. coli* and *Streptomyces* reacted with their homologous cell antisera at dilutions containing 0·15, 0·075 and 0·15 μgm. nitrogen/ml. respectively.

The antigenic pattern of various *E. coli* cultures has been studied in detail by the agglutination test. Kauffmann[2] published a diagnostic scheme for the *E. coli* group based on the distribution of the *H*, *O*, and *K* antigens. This work has been extended by Ewing[3] until there are now 137 standard *O* group cultures and 77 standard *K* antigen strains. Several known serological types were fermented and processed as described previously. In general, the results of the precipitin test on the heated cell-free filtrates were correlated with the cell agglutination tests.

Four methods of recovering added antigenic material from Ohio River water were compared for their effectiveness. The methods were vacuum concentration, sodium sulphate precipitation, adsorption on aluminium hydroxide floc and concentration plus ethyl alcohol precipitation. Only the alcohol (70 per cent v/v) precipitation gave consistent results. The three alcohol-purified antigens could be detected individually or in combinations at a dilution of 3 μgm. antigen nitrogen per litre of Ohio River water. The tube precipitin assay was used because of its simplicity and reliability with multicomponent antigen – antibody reactions. The highly sensitive hæmagglutination inhibition or the complement fixation procedures were not investigated.

The stability, in Ohio River water, of antigenic material from fermentation filtrates was determined under laboratory conditions. While laboratory examination may not reveal the true susceptibility to biological destruction in a receiving stream, it does give an indication. The antigens from the *E. coli*, *Penicillium* and *Streptomyces* filtrates had a stability time of 4–6 days.

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Progesterone in the Blood of the Laying Hen

FRAPS *et al.*[1], using the bioassay method of Hooker and Forbes[2], reported progestational activity in the peripheral blood of the hen. Layne *et al.*[3], using chromatographic procedures, failed to find progesterone in chicken blood although they did identify this substance in extracts of ovarian tissue. In preliminary studies in this laboratory[4], chemical analysis failed to reveal progesterone in blood obtained by cardiac puncture, though the samples reacted positively to the Hooker–Forbes test.

Since progesterone is metabolized by the liver[5], and perhaps by other body tissues as well, a method was devised to minimize such loss. Samples were obtained from White Leghorn hens, six to fourteen months old, between 8.00 a.m. and 4.00 p.m. on the day following oviposition of the initial egg of a sequence. The adrenal glands were cauterized in birds under nembutal anæsthesia, and clamps were placed on the dorsal aorta posterior to the ovarian artery, on both common iliac veins just posterior to the caudal vena cava and on the vena cava anterior to the ovarian veins. The vena cava was opened distal to the last-mentioned clamp, and blood was drawn by suction during the period of 15–25 min. before heart action ceased; 20–35 ml. was obtained from each bird. These samples thus contained a large proportion of blood from the ovary prior to contact with the liver or any capillary bed.

Five samples, each containing 300 ml., were extracted with ethyl acetate by the method of Bush[6]; fat was removed by adding 70 per cent methanol, chilling overnight to − 10° C., and centrifuging at that temperature. The concentrated extracts were run on Whatman No. 2 chromatography paper, using *n*-heptane/methanol/water in the ratio of 5 : 4 : 1 at 38° C., after the method of Bush[6]. Authentic progesterone in this system had an R_F value of 0·73–0·76.

All extracts yielded fluorescent spots, each with the same R_F value as the authentic standard on the same paper. Two of these spots, treated with sodium hydroxide, developed the primrose-yellow fluorescence characteristic of an alpha-beta unsaturated ketone in ring *A*, and one spot, treated with 2,4-dintrophenylhydrazine[7], developed a visible light-yellow colour indistinguishable from that of a similarly treated authentic progesterone. The quantities of progesterone in these three spots, estimated by comparison with progesterone standards, were all more than 10 and less than 20 μgm.; thus, these extracts contained an average of 5 μgm. progesterone per 100 ml. blood. Two spots were eluted with ethyl acetate, and the residue taken up in sulphuric acid for absorption determination[8] at 300 mμ. The amounts determined by this method were, respectively, 4 and 5 μgm. per 100 ml.

Chemical identification of progesterone in these samples was doubtless made possible in large part by circumventing its loss in the peripheral tissues. Improved extraction techniques must also have been important, because earlier samples up to 150 ml. in amount, which were obtained in the same way but were less completely defatted, uniformly failed to yield detectable amounts of progesterone; yet these samples were positive to the Hooker–Forbes test. Application of these techniques to studies of diurnal variation of progesterone-levels in hen's blood will be reported elsewhere.

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Effect of Triiodothyronine on Radiosensitivity

REDUCTION in metabolic rate has been shown to reduce radiosensitivity, but the effect of an elevated metabolic rate has not been well established. Similarly, anoxia induced by various means reduces radiosensitivity. In recent years, the reverse of this phenomenon has been applied in the attempt to increase the radiation response. This is based on the assumption that the radiosensitivity of tissue is related to the degree of oxygen tension in a given tissue at the time of irradiation[1]. Data on the protective action of myxœdema are not extensive; the hyperthyroid state has been shown to hasten mortality in mice given acute lethal doses of total-body irradiation[2,3].

Thyroid hormone is known to produce an increase in the metabolic rate, increased oxygen consumption, flow of blood, and growth potential, demonstrated by enhanced mitotic activity. It was therefore postulated that such stimulation might also lead to an increase in the radiosensitivity of selected local tissues, both normal and neoplastic.

L-Triiodothyronine sodium, the potent fraction of the thyroid hormone that acts rapidly at the cellular level[4], was selected to induce the hyperthyroid state. (L-Triiodothyronine sodium was kindly supplied as 'Cytomel'-sodium by J. Clipson of Smith, Kline and French Research Laboratories.)

Two abnormal tissues were used: (1) a solid, non-metastasizing, non-systemic, myeloid chloroleukæmia rat tumour; (2) a mouse neuroblastoma of similar biological action. The latter tumour is so radio-resistant that it causes the mouse to succumb to the systemic effects of an exposure employed in the local irradiation of this tumour before sufficient time has elapsed for evaluation of tumour response. The rat chloroleukæmia was injected subcutaneously into the flanks of male Sprague–Dawley rats, weighing approximately 250 gm. Within two weeks after inoculation, this tumour attains a size of 2–3 cm. Administration of triiodothyronine was started at this stage; four consecutive doses of 200 μgm. each were given subcutaneously at 48-hr. intervals. Oxygen consumption before X-ray treatment increased 60–80 per cent above normal values. The hyperthyroid state was manifest clinically by excitement and irritability in this otherwise docile host. There was profuse water intake, diuresis and marked and rapid loss in weight despite striking voracity. The fur became rough and lost its sheen. The dosage of triiodothyronine given proved to be in excess of physiological tolerance as evidenced by the appreciable mortality among the animals, even before irradiation. In point of fact, it was observed that the induced hypermetabolic condition persisted for 5 days in the mice and about 10 days in the rats after discontinuation of the drug. The animals were irradiated 3 days after the last administration of triiodothyronine. They were not anæsthetized inasmuch as such treatment might cause changes in metabolic and respiratory rates. As a result, satisfactory immobilization of the exposed tumour-bearing portion of the rat, caged individually in a protective lead box, was not achieved with certainty in every case. Radiation was delivered at several dose-levels above and below the established tumoricidal dose (300–1,500 rads calculated at 1-cm. depth; 0·2-cm. copper H.V.L., 150 kV., 21-cm. F.S.D., 4-cm. cone). Immediately after X-irradiation, the rats were offered drinking water containing 0·05 per cent chloromycetin *ad libitum* in an effort to reduce the bacteræmia, severe diarrhœa, and death that occurs in animals exposed to the higher dosage-levels.

Only 103 of approximately four hundred animals survived long enough to permit adequate evaluation. Tumour response, judged by simple palpation of the treated site, was evaluated one week after X-ray treatment and weekly thereafter for eight weeks. Involution of the tumour until it was no longer palpable was found to occur within four weeks if treatment was adequate. Otherwise, there was a marked increase in size of tumour at this time. Elaborate histological observation transcended the scope of this initial project.

In the group of 52 euthyroid rats, the chloroleukæmia disappeared when a tumour dose of 1,000 plus or minus 200 rads was given. The same tumour, under the same conditions in 51 hyperthyroid rats, disappeared when a tumour dose of 500 plus or minus 200 rads was delivered. In neither group did this variation exceed 10 per cent of the total number of animals treated. The few exceptions in each group that were not cured, even by the largest doses employed, may be attributed to inadequate immobilization during X-irradiation.

When sufficient experimental results had been obtained to support the thesis that increased radiosensitivity resulted from induction of a hyperthyroid state, two patients were selected for such treatment. Both had histologically verified squamous cell bronchogenic carcinoma with widespread metastases. Several sizeable tumour masses protruding from the soft tissue were selected as sites for trial treatment. The patients' basal metabolic rate was raised markedly (above 40 per cent) by triiodothyronine, given orally (400–600 μgm. daily), and was maintained at that level throughout the period of radiotherapy. Regression of tumour masses was unequivocal at one-third the dose-level (1,500 rads) at which such a response might ordinarily be expected. Treatment was suspended at half of the customary therapeutic level (3,000 rads), because the tumour mass could no longer be palpated. The overlying skin also demonstrated an inordinately early and severe radiation response (wet reaction), indicating that the skin reaction was enhanced to a degree.

One patient has been followed for three months, and in this short observation period there has been no recurrence of tumour in the treated sites. During this interval, however, he has had additional metastases in similar sites elsewhere on the body which were irradiated with an identical dose without the benefit of triiodothyronine-induced hypermetabolism. Irradiation alone had little effect on these subcutaneous tumour metastates when the patient was not in a hypermetabolic state.

Whether the profound response that was seen in these hyperthyroid animals and patients reflects only a quantitative change has not yet been determined. It is believed that inasmuch as a basically radioresistant tumour like bronchogenic carcinoma cannot ordinarily be eradicated even by large exposures, there may well have been a fundamental, biological, qualitative change in these neoplastic cells induced by the thyroid hormone triiodothyronine. A series of classically non-radiosensitive human tumours, such as gastrointestinal carcinomas, brain tumours, and connective tissue tumours, is now being subjected to similar investigations, which will contribute to the clarification of this radiobiological response.

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Effect of DDT on Egg-laying by *Oscinella frit* L.

OATS sprayed with DDT soon after emergence largely escape frit fly tiller attack, even on small plots growing within an untreated field. It was not known how DDT confers this protection. Preliminary observations during 1955–56 showed that there were far fewer eggs present on the sprayed than on the

Table 1. Frit Fly Egg Counts and Damaged Shoot Counts on Plots Sprayed and Unsprayed with DDT

Date of sowing	Date of spraying 0·2 per cent DDT miscible	Date of egg sampling	No. of eggs found		No. eggs/plant		Percentage plants with eggs		Percentage damaged shoots	
			Control	DDT	Control	DDT	Control	DDT	Control	DDT
1957 Trial										
April 12	May 3 and 13	May 9	141	116	1·30	1·03	—	—	June 11, 1957	
		May 17	321	65	3·60	0·85‡	78·6	28·8		
		May 27	294	70	4·59	0·92‡	85·9	18·6	41·0	2·1
1958 Trial									May 27, 1958	
Site *A*. April 11	May 2 and 15	May 8	126	21	1·49	0·23*	52·3	10·1		
		May 16	176	107	2·47	1·26*	35·1	32·9	21·4	1·4
									June 16, 1958	
Site *B*. April 29	May 13 and 19	May 20	232	18	1·60	0·14†	41·0	4·3		
		June 4	179	29	2·52	0·43‡	70·4	19·0	37·7	1·9

* Difference significant at $P = 0{\cdot}05$. † Difference significant at $P = 0{\cdot}01$. ‡ Difference significant at $P = 0{\cdot}001$.

unsprayed plots. This was confirmed in replicated trials during 1957–58. The results are given in Table 1.

On all dates but one there were significantly more eggs on the controls than on the DDT plots ($P = 0{\cdot}05$ or $P = 0{\cdot}01$), the average difference being of the order of 75 per cent. It seemed unlikely that this was due to DDT killing the flies quickly and so resulting in far fewer flies on DDT plots, because the plots were small and flies were coming in from outside. A measure of the actual number of flies present was obtained by coating some plants on each plot with a sticky material and recording the flies caught. During May 13–27, 237 flies were caught on 295 plants on DDT plots and 279 flies were caught on 305 plants on the control plots, indicating that the numbers of flies on the treated and untreated plots were substantially similar.

That the reduction in egg laying must have been due to a very local effect was shown as follows. On May 22, eggs were counted on the outer rows of sprayed plots and on the second row of the adjoining control plots so that the sampled rows were about 14 in. apart. There were 1·55 and 0·16 eggs per plant on the untreated and treated rows ($P = 0{\cdot}01$) and eggs were found on 55 and 16 per cent of the plants respectively.

Next, tests were carried out to observe the behaviour of the flies when given the choice of untreated surfaces and surfaces treated with DDT. Batches of 10 females were placed in metal cylinders 8 in. in diameter closed at one end by two joined semicircles of Whatman No. 1 filter paper, one of which had been sprayed either with 0·2 per cent DDT miscible or with 0·2 per cent DDT emulsion and thoroughly dried. Every half minute during 5 min. flies were counted on each semicircle and each test was repeated four times: in all, 135 flies were counted on DDT miscible, 167 on DDT emulsion paper and 191 and 177 flies on the respective untreated semicircles. The differences were not large or consistent and it seemed improbable that, in the field, DDT deterred the flies from alighting or that they had a marked preference for the untreated plants.

Kennedy[1] has found that contact with DDT shortens resting periods of mosquitoes and it is known that excitation generally follows contact with DDT. We tested the behaviour of frit flies by placing batches of 10 females in cylinders closed at one end by a filter paper, either unsprayed or sprayed with 0·2 per cent DDT. Every half or every full minute we counted the flies actually on the papers, those remaining stationary, and the number of flights made in a 15-sec. period.

The results were as follows:

(1) For the first 8 min. there were slightly fewer stationary flies on DDT papers than on the controls: on the average 1·8 and 2·7 respectively. The position was then reversed, the difference increasing with time until by the forty-fifth minute there were 8·0 stationary flies on DDT and 1·5 on the controls.

(2) During the first 6 min. there were 3·7 flights in 15 sec. on DDT and 1·8 on controls. The position was then reversed and there was a continuous reduction of flights on DDT down to 0·5 after 30 min. compared with 5·6 on controls. The results for DDT in the first 8 min. showed wide variations and they require confirmation. However, the gradual reduction of movement after 10 min. on DDT papers was a constant and well-defined feature of all the tests. After 20–30 min. most of the flies remained in one place for several minutes, the only activity being that of cleaning. Paralysis of one or two individuals and lack of response to light were also noted after about 30 min.

Waterhouse and Scott[2] found that DDT prevented the laying of eggs by the sheep blow-fly. The number of flies landing appeared to be similar but there was less searching for oviposition sites on the treated sheep. They concluded: "protection is conferred by an inhibition of one of the early stages in the chain of reflexes leading to oviposition". This probably applies equally well to frit fly, although 'contact repellency' may play some part. Where comparatively large numbers of eggs had been found on treated plots (for example, site *A* in 1958, Table 1) there was afterwards much less damage than expected, suggesting that DDT also acts by killing the newly hatched larvæ.

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A Simple Autoradiographic Method for distinguishing Insects labelled with Phosphorus-32 and Sulphur-35

The use of radioactive tracers for labelling insects is finding many applications in field studies on dispersion and survival. In particular, the introduction of autoradiography for detecting tagged insects[1] has presented entomologists working in remote areas with a simple and practical tool. In

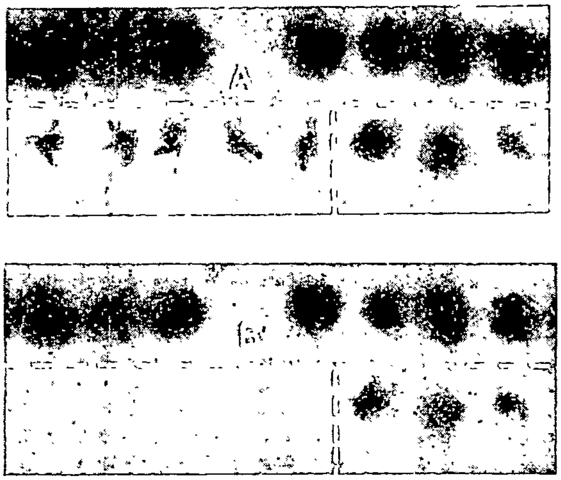

Fig. 1. Autoradiographs of labelled *Anopheles gambiae* after application of the film in two layers; showing, *A*, the first layer of film, in direct contact with the mosquitoes, and, *B*, the second layer. The three divisions in each strip of film represent mosquitoes labelled as follows: upper row, males and females treated with phosphorus-32 at 5 μc./l.: lower row, left, males labelled with sulphur-35 at 20 μc./l.; lower row, right, females with phosphorus-32 at 3·5 μc./l.

studying the longevity of marked populations, however, this technique suffers from the disadvantage that it records only the presence or absence of radioactivity in recaptured insects. No variation in the marking of different releases is possible, and a second release can only be made when all the survivors of the first have disappeared. When the numbers released depend upon the scale of laboratory rearing, as in the case of insects such as *Anopheles gambiae*, this may appreciably retard the accumulation of results. To surmount this difficulty the following method, that enables the separation by autoradiography of insects labelled with one of two or possibly more different isotopes, has been devised.

The method is based on differences in the energy of the radiation emitted by different radioisotopes. Phosphorus-32, the most widely used in entomological research, emits beta-particles with the relatively high energy of 1·71 MeV. It gives excellent autoradiographs. Sulphur-35, which has been used for studies on Lepidoptera[2], emits beta-rays with no more than 0·167 MeV. It gives very sharp images of labelled objects; but its penetrating power is extremely low. Mosquitoes marked with either of these isotopes are readily separated by exposure on strips of X-ray film laid in two superimposed layers. After an appropriate exposure time, blackening of the layer of film in immediate contact with the labelled insects occurs in both cases; but with sulphur-35 the first layer acts as an effective absorber, and prevents any detectable quantity of radiation reaching the second layer. Insects labelled with phosphorus-32 give good autoradiographs through at least four layers of film, while those with sulphur-35 leave an image on the first layer only (Fig. 1).

Sulphur-35, in addition to phosphorus-32, is being used for field studies on *A. gambiae* at concentrations of 10–15 μc./l. (100–150 mμc. per larva) in the breeding pans. Recaptured mosquitoes are laid out for testing on strips of cellulose tape, which are afterwards applied directly to single strips of industrial X-ray film. After an exposure time of one to two nights (16–40 hr.) the films are developed. It is usually possible to distinguish insects labelled with sulphur-35 from those with phosphorus-32 by the sharpness or otherwise of the image. But in every doubtful case confirmation is obtained by re-exposing the same strip of mosquitoes, using this time two layers of film.

The weakness of the images produced by sulphur-35 is offset by the relatively long half-life of 87·1 days. This means that loss of radioactivity through decay is probably slight during the life-time of most tropical mosquitoes. But in the case of phosphorus-32, labelled insects surviving beyond six weeks may be difficult to detect. If recaptures beyond this age are not likely to be encountered, a combination of the two isotopes in the same insects might distinguish them from those labelled with one only. In double-labelled insects, the phosphorus-32 present at the time of capture tends to mask the presence of the sulphur-35; but if all marked recaptures were set aside until the former had decayed sufficiently, say after two or three months, and were then re-tested, the sulphur-35 would still show up. By some such method the separation of three overlapping releases might become possible.

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Cytochromes in Chloroplasts

IT has been concluded from experiments with barley leaves that chloroplasts contain cytochromes f and b_6 and no cytochrome c[1]. We have been able to extend the observations to two other widely differing species and to record certain characteristics of the cytochromes present.

The chloroplasts were obtained from laminæ of *Caulerpa prolifera* growing in the Bay of Naples and from leaves of *Vicia faba* from the adjacent district. They were separated and purified by the method of James and Das[2], which secures a total separation from accompanying mitochondria, etc. Suspensions of the chloroplasts in a mixture of 40 per cent sucrose-phosphate buffer medium[2] with 60 per cent glycerol were examined in 1-cm. cuvettes in a Beckman *DU* spectrophotometer with photomultiplier attachment.

Suspensions were examined as freshly extracted, after reduction with a pinch of dithionite and after decolorization with cold acetone at − 10° C.

The redox difference spectrum of decolorized bean (and also spinach) chloroplasts showed the three absorption maxima to be expected from the presence of a single cytochrome. The magnitudes of the peaks, $\gamma \gg \alpha > \beta$, had also the relations to be expected and the positions were within the usual ranges and were taken to lie as follows: α at 563–564 mμ, β at 526–528 mμ, γ at 430 mμ. Since the cytochrome was 'insoluble' and not denatured by the rapid treatment with cold acetone, it is assumed to be the cytochrome b_6 observed by Hill in barley. The absorption curves of acetone-extracted chloroplasts from *Caulerpa prolifera* were considerably distorted by interfering substances, but peaks were again observable at 562–564 mμ and 430 mμ.

The redox difference spectra of pure suspensions of living chloroplasts showed similar α and γ peaks, and also additional peaks at 556 and 422 mμ suggesting the presence of cytochrome *f* in the undamaged chloroplasts, though in smaller amounts than cytochrome b_6. Similar results were obtained with both *Caulerpa* and *Vicia*.

It was found that if the pure chloroplast suspensions from *Caulerpa prolifera* were illuminated strongly the difference spectrum between illuminated and unilluminated developed peaks in both the visual and Soret regions. After five minutes the peaks in the cytochrome *f* positions (α and γ) were the more conspicuous, but after 20 min. the peaks in the cytochrome b_6 positions were the higher. Bean chloroplasts similarly illuminated also showed similar increases of absorption, but there was a rapid return to the original condition when the light was removed. Rapid reoxidation might be expected of cytochrome b_6, which is readily autoxidizable.

Positions of the α peaks in the visual region corresponded closely in the green and decolorized preparations for both cytochromes; but in the Soret region there were definite divergences. The observed position of the γ bands with the green suspensions was always about 5 mμ higher than with the decolorized material. The position of the γ band of cytochrome *f* in the decolorized bean material was at 422 mμ, which corresponds well with the value 421 mμ given by Davenport and Hill[3] for extracted cytochrome *f*. It is presumed that the apparent shift of the peak in the green chloroplasts is due to interfering pigments removed by the acetone.

According to our observations the positions of the absorption maxima are as follows:

Cytochrome	*f*		b_6		
Absorption band	γ	α	γ	β	α
Caulerpa prolifera	423*	555	430	—	563
Vicia faba	422	556	430	528	564

* Adjusted value from observation of 428 mμ with green chloroplasts.

Cytochrome *c* was never found in chloroplast suspensions freed from any accompanying mitochondria, but a very small contamination sufficed to make the characteristic α band visible at 550 mμ.

Further details of these observations are being published in the *Pubblicazione della Stazione Zoologica di Napoli.*

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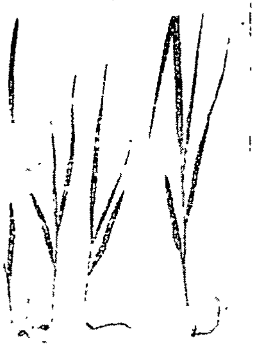
Translocation of ^{14}C-labelled 2,4-Dichlorophenoxyacetic Acid in Barley and Oats

The 'hormone' herbicides 2-methyl-4-chlorophenoxyacetic acid (MCPA) and 2,4-dichlorophenoxyacetic cid (2,4-D) have repeatedly been shown to produce deformities in the straw and spikes of cereal plants when applied before five or six leaves have developed. This connexion between deformation and age of plants as led to the assumption that floral and vegetative primordia are particularly sensitive to compounds with hormone activity but become more resistant with progressing development. Experiments with 2,4-D labelled with carbon-14 in the carboxyl group, however, suggest that this is scarcely likely to be the true explanation.



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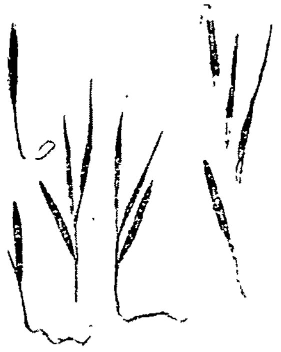

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Fig. 1. Barley plants, 1–4 leaf stage
Fig. 2. Radioautograph of the plants in Fig. 1

Seedlings of barley and oats were given applications of 10 μl. of a 0·5 per cent solution of labelled 2,4-D (total activity, 0·3 μc.) at the centre of the upper surface of each leaf. The plants were treated at six stages: 1, 2, 3, 4, 5 and 6 leaves; the total dose of 2,4-D applied was thus 10 μl. multiplied by the number of leaves. This corresponds to field practice where plants with 5 or 6 leaves receive and take up very nearly 5 or 6 times as much 2,4-D as those with a single leaf.

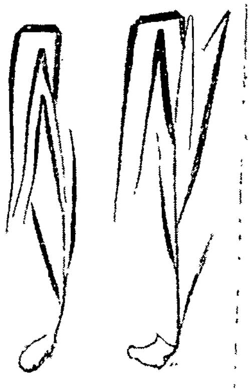
After application, which occurred in the morning, the plants were left 4–8 hr. in a greenhouse with artificial illumination. The plants' roots were then rinsed of soil, the area of application was covered with adhesive paper, and the plants were placed between several layers of warm blotting paper in a high-glazing photographic press, where they were killed by heating to 60° C. for 15 min.

Immediately afterwards the plants were mounted with rubber cement on white cartons and pressed to paper thinness in a specially constructed press. (A freeze-drying unit as recommended by Crafts[1] for desiccation of plants was not available.) After desiccation and pressing for about a week the plants were placed on X-ray films for radioautography; the period of exposure was three weeks.

Barley plants in the stages of one, two and three leaves are seen in Fig. 1 and the corresponding radioautographs in Fig. 2. The radioactive 2,4-D is in these young plants effectively translocated from the point of application to the stem and through the stem to the roots, thus passing through the floral and vegetative primordia.

Figs. 3 and 4 show barley plants in the 5–6 leaf stage and the corresponding radioautographs. At this stage of development translocation is slight and does not extend to the stem and roots as it does in younger plants.

Oats, in contrast to barley, show little translocation in the early stages (1–2 leaves); 2,4-D is not transferred to the hypocotyle, the seed and the roots to such an extent as in barley, and will thus come in contact with the embryonic primordia to a smaller extent. Translocation in oat plants becomes effective in the 3–4 leaf stage when 2,4-D is detected in all parts of the plants. Later, in the 5–6 leaf stage,



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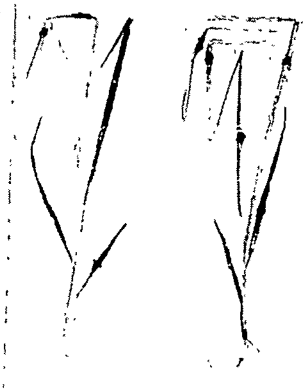

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Fig. 3. Barley plants, in 5–6 leaf stage
Fig. 4. Radioautograph of the plants in Fig. 3

translocation again becomes slight and the active compound remains largely in the leaves, as in barley.

Histological detection of labelled 2,4-D in floral primordia of plants at different stages of development was attempted in exploratory experiments (Petersen *et al.*, unpublished). These attempts, however, were unsuccessful.

In order to test whether floral primordia in older plants are susceptible to 2,4-D, barley and oat plants were given syringe injections of a single drop of 0·5 per cent 2,4-D solution in the leaf sheath immediately above the floral primordium. The plants responded very strongly with formation of tubers near the soil surface and twisting and cracking of the stems in several places ; the floral primordium was mostly strongly deformed or altogether destroyed, even in plants older than the 5–6 leaf stage.

The reason why cereals do not develop deformed spikes or stems on treatment with 2,4-D after the 5–6 leaf stage may thus be the lack of translocation and not necessarily an increasing degree of resistance in the vegetative and floral primordia.

Similar experiments with wheat and rye are in progress.

I am greatly indebted to Prof. A. S. Crafts and to Dr. H. Levi for instruction in their technique of tracer studies.

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Effect of Rust Infection on Oxidative Phosphorylation of Wheat Leaves

WE have already reported[1,2] that the rate of consumption of oxygen by wheat leaves infected with stem rust fungus is not augmented by treatment with 2,4-dinitrophenol, in contrast with the great respiratory increase observed in healthy leaf tissue after treatment with dinitrophenol.

This observation is strikingly related to the well-established fact that the consumption of oxygen by leaf tissues infected with rust is also significantly increased, and that the glycolysis and further respiratory pathways linked with stimulated glycolysis play an important part in the respiratory metabolism of diseased but not of healthy wheat[2]. There is an analogy between the physiological effects of infection with rust and those of treatment with dinitrophenol Therefore, on the basis of the results obtained i seemed reasonable to suppose that the ineffectivenes of dinitrophenol in the case of tissues infected wit rust is due to the fact that the pathological respirator mechanism has already undergone alterations simila to those which occur in healthy leaves as a resul of treatment with dinitrophenol[3].

It is widely accepted that 2,4-dinitrophenol exert its stimulatory effect on biological oxidation an especially on glycolysis by interfering with th normal phosphorus metabolism. It has been demonstrated that treatment with dinitrophenol resulted i increased adenosine triphosphatase activity, in consequence of which a higher level of P-acceptor (adenosine diphosphate) is available. This allows a greate rate of breakdown of sugar and an enhanced uptak of oxygen[4]. To gain a deeper insight into the mechanism of respiratory increase due to infection with rus fungus and to dinitrophenol, comparative analyse for phosphate fractions of healthy and affected leave were made.

Wheat plants (Hungarian rust-susceptible variet *R*23) were grown under ordinary greenhouse conditions. The primary leaves were inoculated with a suspension of stem rust (*Puccinia graminis*, race 21 uredospores. On the fourteenth day after infectio leaves were collected from both healthy and disease plants and assayed for phosphate by a modificatio of the Lowry–Lopez method[5]. 2,4-Dinitrophenol i a concentration of 10^{-4} *M* was absorbed into the lea tissues.

Table 1 shows that the amount of the phosphat fraction labile to acid decreased significantly i plants infected with rust as compared with health ones. The amount of phosphate labile to acid in th phosphate fraction soluble in acid, and free fro nucleoproteins, phospholipids and phosphoprotein also decreased. (In the experimental conditions use phosphate labile to acid represents the inorgani phosphate released principally from adenosine tri and di-phosphate.) A slight but definite statisticall significant increase was also demonstrated in th amount of inorganic phosphate fraction. These results strongly suggest that infection results i destruction of adenosine triphosphate.

In uninfected leaves, following absorption c 2,4-dinitrophenol (Table 2), the amount of acid-labil phosphate decreased, as in the case of rust infectio but to a greater extent. A concomitant increase o inorganic phosphate was also observed.

In the cases of treatment with dinitrophenol an of rust infection, as compared with water-infiltrate and uninfected healthy plants respectively, a diminution of total organic phosphate and of the organi phosphate of the fraction soluble in acid occurred

Table 1. PHOSPHATE FRACTIONS OF HEALTHY AND RUST-INFECTE WHEAT LEAVES
(Mean values of five experiments in three series)

Fraction	μgm. Phosphate/100 mgm. fresh weight: Healthy	Diseased
Total phosphate	105·4	97·4
Inorganic phosphate	65·5	70·2
Organic phosphate	39·9	27·2
Acid-labile phosphate*	15·4	3·5
Acid-labile phosphate* of the acid-soluble fraction	14·7	3·5
Organic phosphate of the acid-soluble fraction	16·8	9·8

* Increase of inorganic phosphate after hydrolysis with *N* hydr chloric acid at 100° C. for 7 min.

Table 2. EFFECT OF WATER AND DINITROPHENOL ON PHOSPHATE FRACTIONS OF HEALTHY WHEAT LEAVES
(Mean values of five experiments in three series)

Fraction	gm. Phosphate/100 mgm. fresh weight: 24 hr. after water infiltration	gm. Phosphate/100 mgm. fresh weight: 24 hr. after dinitrophenol infiltration (10^{-4} *M*)
Total phosphate	65·6	59·8
Inorganic phosphate	36·0	56·2
Organic phosphate	29·6	3·6
Acid-labile phosphate*	8·8	0·4

* Increase of inorganic phosphate after hydrolysis with *N* hydrochloric acid at 100° C. for 7 min.

These results clearly show that an anabolic alteration of metabolism connected with rust infection, namely, a synthesis of organic phosphate and an incidental activation of a system by which the energy of adenosine triphosphate is utilized, and a simultaneous decrease in the phosphate fraction labile to acid cannot occur. Although an increase in the nitrogenous fraction insoluble in acid (such as protein) has been observed after infection, this phenomenon is explained by the spread of fungal body in the leaf tissues. At the same time, we found no increase but, on the contrary, a decrease of organic phosphate fraction. Destruction of acid-labile phosphate and organic phosphate in diseased plants reaches such a high level that it predominates over the synthesis of organic phosphate arising incidentally from the growth of fungal body. There seems to be no necessity, therefore, for postulating that the synthetic reactions of fungal metabolism utilize the energy of adenosine triphosphate and thus accelerate the reaction:

$$\text{ATP} \rightarrow \text{ADP} + \text{P}_i \qquad (1)$$

The experimental results rather support the view that the infection (by a toxic action) inhibits the rate of oxidative phosphorylation just as in the case of treatment with dinitrophenol. In both cases oxidative phosphorylation is uncoupled from respiration and this gives rise to a greater amount of phosphate acceptor (adenosine diphosphate) and inorganic phosphate. These compounds govern the reactions controlling the rate of glycolysis and of the whole process of respiration, as pointed out by Krebs[6].

This rate-controlling function of inorganic phosphate and adenosine triphosphate explains the effect of rust infection. The destruction of acid-labile phosphate (first of all adenosine triphosphate) and the simultaneous increase of inorganic phosphate by acceleration of reaction (1) create a high level of both phosphate acceptor and of inorganic phosphate in the diseased tissues, and the availability of these two compounds gives rise to a pathologically high rate of respiration.

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Occurrence and Metabolism of Oligosaccharides in the Broad Bean (*Vicia faba*)

PAPER chromatographic analysis of aqueous methanolic (75 per cent v/v) extracts of dormant broad bean seeds using (*A*) ethyl acetate/acetic acid/formic acid/water (9·0 : 1·5 : 0·5 : 2·0 v/v) and (*B*) ethyl acetate/pyridine/water (10 : 4 : 3 v/v) as solvents with *p*-anisidine hydrochloride as spray reagent[1] showed that both the embryos and cotyledons contained small amounts of raffinose, glucose and fructose together with relatively high concentrations of sucrose and higher molecular weight oligosaccharides. Traces of xylose were also detected (cf. Kawamura, Tsuboi and Nakamura[2]). The testa contained only glucose and fructose.

A large-scale extract of whole beans was concentrated to a syrup and fractionated on a carbon–'Celite' column[3]. The oligosaccharides present were identified as: sucrose [m.p. 178° C. (anhydrous), $[\alpha]_D^{20} + 64{\cdot}3$ (conc. 2·8), octaacetate m.p. and mixed m.p. 84–85° C.]; raffinose [m.p. 117–120° C. (anhydrous), $[\alpha]_D^{20} + 123{\cdot}5$ (conc. 1·1)]; stachyose [$[\alpha]_D^{20} + 145°$ (conc. 1·5, anhydrous), consumed 7·0 moles of periodate per mole] and verbascose [infra-red spectrum identical with that of authentic verbascose; consumed 8·8 moles of periodate per mole]. The identity of the oligosaccharides was further proved by a comparison of their electrophoretic (0·2 *M* borate buffer, *p*H 10) and chromatographic behaviour (in solvents *A* and *B*) with that of authentic specimens, and also by a study of the hydrolysis products obtained with sulphuric acid (0·5 *N*) and yeast invertase. Electrophoretic and chromatographic evidence for the presence of a tetragalactosylsucrose in the extract was also obtained.

Germination of the beans on moist filter paper (25° C.) resulted in a rapid disappearance of the higher oligosaccharides from all parts of the seeds, leaving sucrose and an increased concentration of glucose and fructose.

The carbohydrase activity of embryos and cotyledons from both dormant and germinated (5 days) beans was examined. The tissues were macerated with cold acetate buffer (0·2 *M*; *p*H 5·6) and, after centrifugation, the solutions dialysed against buffer at 5° C. The ability of these preparations to hydrolyse sucrose, raffinose (producing free galactose) and maltose (at 35° C. under toluene using 5 per cent w/v substrate concentrations) was taken as an indication of the presence of sucrase, α-galactosidase and maltase, respectively, in the tissues. The digests, together with suitable controls, were examined on paper chromatograms after 48 hr. (Table 1).

Attempts to obtain an active sucrase preparation from dormant embryos by extraction with buffers of varying *p*H (4·5, 5·6 (0·2 *M* acetate) and 6·4 (0·1 *M* phosphate)) containing L-cysteine (10^{-3} *M*) were unsuccessful. Sucrase rapidly appeared, however, in excised embryos which were allowed to rest on moist filter paper (25° C.). Quantitative measurements of sucrase activity in germinated embryo

Table 1

Carbohydrase	Dormant		Germinated	
	Embryo	Cotyledon	Embryo	Cotyledon
Sucrase	–	–	+++	–
α-Galactosidase	+	+	++	+
Maltase	+	+	+	+

preparations, using the Somogyi reagent[4], showed that the addition of a dormant embryo extract had no inhibitory effect. It would appear, therefore, that sucrase is synthesized in the embryonic tissues in the early stages of germination, and it is probably not present in a latent form in the dormant tissues. Hora[5] has also demonstrated sucrase formation in germinating barley. Germinated embryo preparations (pH 5·6; 35° C.; 48 hr.) degraded stachyose and verbascose with the liberation of galactose, glucose and fructose in both cases. With dormant cotyledon preparations under the same conditions, however, the only free monosaccharide liberated was galactose.

During these studies it was observed that the sucrase in germinated embryos was strongly inhibited (at 10^{-3} M concentrations) by mercuric chloride and phenylmercuric acetate and to a lesser extent by iodoacetic acid. An aqueous extract of the bean testas also behaved as an inhibitor.

The role of sucrase in the plant is not understood. In the case of the germinating bean seed the increase in reducing substances together with the appearance of sucrase activity may be significant. The rapid disappearance of galactose-containing oligosaccharides from the germinating tissues and the absence of significant quantities of free galactose suggest that the former compounds may form an important sugar reserve for the developing plant.

A full report of this work will be given in a later publication.

I wish to thank Prof. E. L. Hirst for helpful discussions, Prof. E. J. Bourne for valuable suggestions and Prof. J. E. Courtois for a specimen of verbascose.

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Inhibition of Sulphate Reduction in Paddy Soils

THE hydrogen sulphide formed in waterlogged soils is a serious problem in rice cultivation. It inhibits the uptake of water and nutrients, and may even cause root-rot[2-6]. The disease due to these injurious effects (browning disease, 'brusone', brand, aki-ochi, etc.) in unfavourable weather conditions, chiefly too little sun (1949, 1954 and 1955), caused considerable damage in Hungary. Injury appeared mainly after stem elongation, when the oxygen supply to the roots is greatly reduced[1].

My previous experiments for controlling the injuries showed that results can best be obtained not by binding the hydrogen sulphide, but by preventing its formation. It is formed mainly by reduction of sulphate, for which the cellulose–butyric acid fermentation provides the hydrogen source[5,6].

To eliminate the hydrogen required for the reduction, experiments were carried out in the laboratory and in the field. 1·5 gm. cotton was placed between wet rice soil-disks in containers after soaking in 30–80 mgm. per cent ammonium and sodium sulphates or in 30–50 mgm. per cent ammonium or potassium nitrate. 14 days after waterlogging and incubation 8·8–26·0 mgm. sulphide per container was formed in the controls and in the containers with sulphates. No sulphide was found in the containers with nitrates.

The atomic hydrogen, formed by butyric acid fermentation, is used to reduce nitrate, and, consequently, cannot be utilized by the sulphate-reducing bacteria as a source of energy.

Experiments in the field also yielded positive results: for this purpose ammonium nitrate mixed with powdered lime ('Péti só') proved to be the most suitable.

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An Aphid-transmitted Tobacco Ring-Spot-like Virus isolated from *Begonia tuberhybrida*

Begonia semperflorens was reported as a host plant for tobacco ring-spot virus by Price[1], but no record of natural infection of begonia with this virus is known.

A plant of *Begonia tuberhybrida* multiflora with leaves showing yellow spots surrounded by a necrotic line was tested for virus infection. The symptoms on tobacco plants, variety Samsun, and cucumbers, variety Blanc hâtif, inoculated with sap were similar to the symptoms described by several workers for plants infected with viruses of the tobacco ring-spot group.

The inactivation temperature in tobacco sap after 10 min. heating was about 70° C.

The virus was easily transmitted by *Myzus persicae* from tobacco to cucumber (1–2 min. acquisition feeding after 2–3 hr. starvation; 24 hr. inoculation feeding; 10 aphids a plant).

Tobacco ring-spot viruses are not usually transmitted by aphids. McWorther[2] reported that a virus of this group isolated from leguminous plants was transmitted by aphids, but only in company with pea enation mosaic virus. Smith and Brierley[3] reported transmission by aphids of tobacco ring-spot virus from gladiolus to gladiolus, but in conditions that did not completely secure the absence of bean yellow mosaic virus, which is prevalent in this plant.

Our results confirm that viruses of the tobacco ring-spot group can be transmitted by aphids; in our conditions, bean yellow mosaic virus was not present in combination, and the absence of cucumber mosaic virus was secured by a cross-protection test.

The virus isolated from *Begonia* did not protect tobacco plants against infection by the type strain of tobacco ring-spot virus.

Thanks are due to Prof. R. Vanderwalle for criticism of this work and to Dr. K. M. Smith for material infected with virus.

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Chitin in Pogonophora

POGONOPHORA secrete and inhabit tough, horny tubes. Recently, Hyman[1] quoted unpublished results indicating that the tubes of Pogonophora were composed of cellulose. In view of the presumed phylogenetic relationship of Pogonophora with lower chordates this might have been expected, since the tunicate test is rich in cellulose (tunicin). However, on examining three species of *Siboglinum* (*S. atlanticum* Southward and Southward, *S. inermis* Southward and Southward[2], and *S. caulleryi* Ivanov) kindly given to us by Dr. A. J. Southward, we found the tubes to be lacking cellulose, but rich in chitin. Later, through the kindness of Academician Ivanov, we were given specimens of the tubes of *Zenkevitchiana longissima* Ivanov[3], and the same conclusion about their composition was reached.

Tubes of the four species available withstood treatment for 20 min. in saturated aqueous potassium hydroxide at 150° C. The alkali-treated tubes, after washing, were coloured brown by iodine in potassium iodide solution, becoming violet when this was replaced by dilute sulphuric acid[4]. Alkali-treated tubes were soluble in mineral and acetic acids. Both cellulose and chitin are relatively stable in alkali, under the conditions specified; but the above colour reactions, and solubility in acids, are properties shown only by chitin[5]. The tubes resisted solution in Schweitzer's cuprammonium reagent, in which cellulose dissolves; and the same result was obtained if tubes were pretreated in strong alkali (as above) or in a solution of chlorine dioxide in acetic acid ('diaphanol').

Chitin, being considered as a polymer of 2-acetamido-2-deoxy-α-D-glucopyranose (N-acetyl-D-glucosamine), on acid hydrolysis yields D-glucosamine; and, on enzymic degradation, N-acetyl-D-glucosamine[6]. The pogonophoran tubes showed these reactions.

Tubes of the four species were hydrolysed in sealed vessels with 6 *N* hydrochloric acid at 100° C. for 6 hr. After drying the hydrolysate over phosphorus pentoxide and potassium hydroxide, the residue was taken up in water and run on partition paper chromatograms against D-glucose and D-glucosamine hydrochloride, using eight different solvent mixtures. The chromatograms were sprayed with aniline hydrogen phthalate, silver nitrate, or the Elson and Morgan reagents. A substance (evidently an amino-sugar) behaving like glucosamine (or galactosamine) was present in large amounts; but no glucose was detectable. On conversion to the corresponding pentose by Stoffyn and Jeanloz[7] procedure *B*, the acid hydrolysate of *S. atlanticum* yielded arabinose, confirming the presence of glucosamine (as opposed to galactosamine).

Tubes of *S. atlanticum* were prepared for enzymic hydrolysis by heating with 4 *N* aqueous potassium hydroxide at 100° C. for 3 hr. (to remove the substances other than chitin mentioned below), and the residual chitin was dispersed by brief treatment in 12 *N* hydrochloric acid; after washing, the suspension was incubated at 37° C. with an enzyme preparation from the puff ball *Lycoperdon pyriforme*[5], buffered at *p*H 5·0, having chitinase and cellulase activity. Samples taken after 18, 42 and 66 hr. were concentrated *in vacuo* and chromatographed in butanol/ethanol/water (4 : 1 : 5). N-acetyl-glucosamine was shown to be present with the Elson and Morgan reagent, and no glucose was detectable with aniline hydrogen phthalate.

Proteins invariably accompany chitin, and a number of amino-acids were found in the acid hydrolysate of the tubes. These amino-acids must have been derived from a very stable protein in so far as it withstands environmental dissolution; but it is not yet known whether stabilization is derived from disulphide links (being a keratin), or quinonoid links (being a sclerotin).

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Production of Experimental Scurvy in a Bird Species

IT has been generally supposed that all species of animals except the primates and the guinea pig are able to synthesize ascorbic acid according to their requirements. In a previous communication[1], using our technique of incubating liver and kidney tissues of different species of animals with D-glucuronolactone as substrate in presence of cyanide, it was shown that in some species the kidney could effect the synthesis and in some the liver. In the evolutionary ascent the mechanism for the synthesis of ascorbic acid appeared to pass from the kidney to the liver and then to disappear altogether. It was also unexpectedly observed that neither the liver nor the kidney tissue of the red-vented bulbul (*Pycnonotus cafer*, Linn.) and of the Indian fruit-bat (*Pteropus medius*) could effect the synthesis. Thus at least one avian species, the red-vented bulbul, and one mammalian species, the Indian fruit-bat, were apparently incapable of synthesizing ascorbic acid. It was suggested, therefore, that the cyanide technique might offer a simple means for determining the capacity of different species for the synthesis of ascorbic acid. This supposition has now been proved to be correct by actually placing some red-vented bulbuls on a scorbutic diet and producing in them ascorbic acid deficiency symptoms, which could be cured by ascorbic acid.

Nine red-vented bulbuls were put on a diet of parched gram powder for a fortnight to get them used to the diet. Then they were placed on the scorbutic diet composed as follows: 80 parts of parched gram powder (autoclaved as an aqueous paste at 18 lb. per sq. in. pressure for 45 min.), 12 parts of casein, 5 parts of yeast powder, 1 part of Steenbock's salt mixture No. 40 and 2 parts of cod-liver oil. The average weight of the birds fell gradually from 35 gm. to 28 gm. in 15 days and they all showed deficiency symptoms. These were loss of feathers and particularly the tail, drooping of the head, sluggishness and peevishness. On the sixteenth and seventeenth days, two birds dropped steeply in weight and died. Then three birds, which were in the worst condition, were given a daily supplement of 3 mgm. of pure ascorbic acid dissolved in 0·1 c.c. water by mouth and the four remaining birds were allowed to continue on the scorbutic diet only. All the three birds which received the ascorbic acid supplement began to gain weight and after 10–12 days of feeding the supplement the feathers and the tail began to grow, the birds became brighter in appearance and sat on perches and were obviously getting well. The four birds which were left on the scorbutic diet only became worse and died one after another on various dates in the course of 45 days.

At autopsy the scorbutic birds showed subcutaneous hæmorrhage, hæmorrhage inside joints, particularly knee joints, and in the liver.

In order to find whether, as a contrast to the red-vented bulbul, another avian species, the bank-myna (*Acridotheres ginginianus*, Latham), which was shown by the cyanide technique to be capable of synthesizing ascorbic acid, would be independent of an exogenous supply of ascorbic acid, two birds of this species were placed on the scorbutic diet, and they have continued to be healthy for a period of 72 days.

Our thanks are due to the Indian Council of Medical Research for a research grant.

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Oct. 7.

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A Soil Fungus Trap

THE screened immersion-plate method[1-3] for isolating soil fungi has the disadvantages that the plates are not very simple to make and are not suitable for use in stony ground. In addition, when a pit is dug or a cut is made for insertion of plates, the gas relations of the soil are disturbed and some drying of the exposed surface occurs, and these factors may influence the growth of fungi. A development of the screened immersion plate which appears to show promise in overcoming these disadvantages is described here. Essentially the method involves the removal of a soil core and its replacement by a tubular version of the screened immersion plate within one piece of apparatus. The apparatus consists of a stainless steel rod which fits quite closely into a stainless steel tube. Water agar is contained in a number of holes bored through the rod which oppose the same number of holes bored in the tube. A metal stop on the rod fits into two slots in the tube and ensures alignment of the two sets of holes. The lengths of rod and tube employed, and the arrangement of the metal stop and of the holes are such that, when assembled, the section of rod with the agar-filled holes occupies only half the length of the tube. When the unoccupied half of the tube is pushed into soil a core or plug is cut. When the tube is pushed farther, the core and the soil ahead are compressed farther, and the cored space is then occupied by the section of the tube containing the rod. This enables exposure of the agar to a soil surface, through the apertures in the tube, in much the same manner as in screened immersion plates. The soil surface thus exposed has been little disturbed, and isolation of those fungi capable of growing from soil on to the agar can readily be effected. The compression of the soil involved in the removal of the core occurs beyond the area of soil to be sampled and will have little effect on the growth of fungi.

The method used in recent experiments is described briefly as follows. Rod and tube, unassembled, were placed in a large test-tube and sterilized by dry heat (160° C. for 1 hr.). After cooling, sterile water agar was dispensed into the holes in the rod with a hypodermic syringe under aseptic conditions. The rod was inserted into the tube with the agar-filled holes turned away from the apertures in the tube, and carried into the field in a plugged, sterile test-tube. A small hole was dug and the trap pushed horizontally into the soil profile at the required level with the tube apertures lowermost. The rod was then turned so that the stop fitted the slots and thus brought the holes filled with agar opposite the apertures in the tube. The soil dug out was replaced and the trap left for four to seven days depending on the growing season. Before digging up, the rod was rotated to turn the holes filled with agar away from the apertures in the tube and then the trap was removed bodily and placed in a sterile container. In the laboratory the agar plugs were punched out of the rod on to a nutrient medium in Petri dishes and incubated for further study.

The dimensions of the rod and tube now employed are:

Tube (prepared from 22 gauge stainless-steel tube, outside diameter $\frac{5}{16}$ in.) 4 in. long, with three apertures, $\frac{3}{32}$ in. in diameter, centres $\frac{1}{2}$ in. apart, bored in the first 2 in. of the tube, the distal aperture centre being $\frac{1}{4}$ in. from the centre of the length of the tube.

Rod (prepared from stainless-steel rod, diameter $\frac{1}{4}$ in.) $3\frac{1}{2}$ in. long, with three holes, $\frac{3}{32}$ in. in diameter, bored through it, the first hole centre $\frac{1}{4}$ in. from one end of the rod, the metal stop, made by pushing an $\frac{1}{8}$-in. diameter stainless steel wire through a hole in the rod, 2 in. from the same end of the rod.

The edge of the tube which is pushed into the soil is suitably bevelled on the inside to provide a good cutting edge. The trap is pushed into the soil by pressing on the exposed end of the rod with a small wooden handle, the thrust being imparted to the tube by the metal stop. The metal about the apertures was lightly filed to prevent packing of soil in the apertures when the trap is pushed into the ground.

In experiments in soil under perennial ryegrass a number of fungi have been isolated which included *Fusarium culmorum*, *Cylindrocarpon radicicola*, *Rhizoctonia* sp., *Mortierella* spp., and a number of non sporing forms, all of which had been isolated also b screened immersion plates from the same soil.

I wish to acknowledge the helpful discussions I ha with Dr. R. D. Northey and Dr. K. Strzemienski i the development of this technique.

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Wellington, New Zealand.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, December 15

Royal Aeronautical Society (at the Institution of Mechanical Engineers, Birdcage Walk, London, S.W.1), at 9.45 a.m.—All-day Discussion on "Hypersonic Flow".

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. C. L. S. Gilford: "The Acoustic Design of Talks Studios and Listening Rooms".

Royal Aeronautical Society (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. H. G. Conway: "Drone Aircraft".

Institute of Metal Finishing (at Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. J. P. Dewar: "Trends in Polishing".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Colonel G. R. Laclavere: "Antarctica and the I.G.Y.".

Tuesday, December 16

Royal Society of Arts, Commonwealth Section (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Dr. L. Dudley Stamp: "Land Utilization in the Commonwealth".

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Modern Control Techniques on the Railways" opened by Mr. W. J. Webb and Mr. L. A. Ginger.

Plastics Institute, London and District Section (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Mr. V. H. Wentworth: "Plastics in the Construction of Buildings".

Tuesday, December 16—Wednesday, December 17

Powder Metallurgy Joint Group of the Iron and Steel Institute and the Institute of Metals (at Church House, Great Smith Street, London, S.W.1)—Symposium on "The Powder Metallurgy of Ceramic-Metal Materials".

Wednesday, December 17

University of London (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. J. M. Barnes: "Experimental Study of Toxic Substances".*

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. R. C. Rainey: "Some Observations on Flying Locusts and Atmospheric Turbulence in Eastern Africa"; Mr. C. G. Johnson: "Vertical Distribution of Aphids in the Air and the Temperature Lapse Rate".

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Short papers on "The Work of the Boiler Availability Committee" presented by Mr. F. W. Lawton, Mr. H. E. Crossley, Mr. D. C. Gunn, Mr. W. F. Harlow, Mr. J. R. Jenkinson and Mr. W. G. Marskell.*

Institution of Chemical Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. J. W. Mullin: "Liquid Distribution in Grid Packings. Part 1: The Mechanism of Liquid Spread". Part 2: "Evaluation of Packing Constants".

Society of Chemical Industry, Food Group—Nutrition Panel at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Dr. J. P. Masterton and Mr. T. C. Gallant: "Nutritional Problems in Polar Regions, Part 2".

British Institution of Radio Engineers, London Section (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. I. J. P. James: "A Vidicon Camera for Industrial Colour Television".

Oil and Colour Chemists' Association, London Section (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 7 p.m.—Mr. F. E. Warner: "Common Problems and Chemical Engineering".

Thursday, December 18

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 2.30 p.m. and 5.30 p.m.—Scientific Papers.

Institution of Mining and Metallurgy (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. Hulbert Marchandise: "Adsorption Kinetics Applied to Flotation"; Dr. H. N. Rhoden: "Structure and Economic Mineralization of the Silvermines District, County Tipperary, Eire".

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. L. C. Young: "Some Geometrical Inequalities".

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Mr. J. C. R. Dow and Mr. L. A. Dicks-Mireaux: "A Study of Wage Inflation in the U.K. 1946–56".

Royal Aeronautical Society (at the Institution of Mechanical Engineers, Birdcage Walk, London, S.W.1), at 6 p.m.—Mr. E. W. Pike: "The Traffic Control Over the North Atlantic".

Friday, December 19

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 2.30 p.m. and 5.30 p.m.—Meeting on "Modern Views of Fundamental Electrochemical Processes". Mr. E. C. Potter: "Cathodic Processes"; Mr. T. P. Hoar: "Anodic Processes".

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Captain G. S. Ritchie, D.S.C., R.N., and Captain A. J. R. Tyrell: "The Admiralty Chart".

Institution of Mechanical Engineers (at 1 Birdcage Walk, London, S.W.1), at 6 p.m.—Mr. P. Daniel: "The Hydraulic Turbine in Evolution" (James Clayton Lecture).

Friday, December 19—Saturday, December 20

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m. daily—Symposium on "Experimental Approaches to the Problems of Growth and Form in Plants".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Ecologist (man, with a first- or second-class honours degree and preferably some knowledge of statistics), to join a team studying marine plankton using continuous plankton recorders—The Officer-in-Charge, Oceanographic Laboratory, Scottish Marine Biological Association, 78 Craighall Road, Edinburgh 6 (December 20).

Microbiologist (with a good honours degree in botany or agricultural botany) at the Welsh Plant Breeding Station, for work associated with the breeding of new strains of clover—The Registrar, University College of Wales, Aberystwyth (December 20).

Senior Scientific Officer (with a science degree of a university of the United Kingdom with passes in biochemistry, zoology, botany, etc., and preferably five years experience in serology in the Health Service basic grade of Scientific Officer) at the Blood Transfusion Centre, Oxford—The Director, Regional Blood Transfusion Centre, Churchill Hospital, Headington, Oxford (December 20).

Scientific Assistant (with a biological degree, the ability to write correct English and preferably some knowledge of foreign languages), for work which includes the abstracting and reviewing of biological literature—The Director, Commonwealth Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge (December 31).

Senior Lecturer in Mathematics at the University of Natal, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, December 31).

Professor of Agricultural Botany—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (January 1).

Applied Mathematician (with a university honours degree in applied mathematics or in physics, chemistry or a branch of engineering with evidence of suitable attainment in applied mathematics, preferably in hydrodynamics or aerodynamics) in the Chemical Engineering Section, Chemical Research Laboratories, C.S.I.R.O., Fishermen's Bend, Melbourne, initially to collaborate with an experimental team investigating the formation of boundary layers in two-phase fluid systems—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 590/689 (January 3).

Grade II Lecturer (with a genuine interest in inorganic chemistry, preferably on the preparative side and possibly with radiochemical experience) in Inorganic Chemistry—The Registrar, The University, Bristol (January 10).

Chair of Psychology in the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, January 15).

Lecturer in Pure Mathematics—The Secretary, The Queen's University, Belfast (January 15).

Chair of Medicine tenable at the Royal Free Hospital School of Medicine—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 19).

Senior Lecturer in Mechanical Engineering—The Registrar, The University, Sheffield (January 31).

Senior Lecturer or Lecturer (Physiologist, with special interests in either general or cellular physiology) in Zoology at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 31).

Plant Physiologist (with a good honours degree) at the Unit of Experimental Agronomy, Agricultural Research Council, Oxford, to work on fundamental aspects of phytotoxicity and the mechanisms of the actions of herbicides—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (February 1).

University Demonstrator in Bacteriology—Dr. G. P. Gladstone, Sir William Dunn School of Pathology, The University, South Parks Road, Oxford (April 1).

Agricultural Education Officer (with a university degree, considerable experience in tropical agriculture and teaching ability) in the Department of Agriculture's Training Centre, British Honduras, to take charge of, and to teach, the fundamental principles of agriculture to trainees—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/31/09.

Analytical Chemists (with at least H.N.C. or good "A" levels in G.C.E.) at U.K.A.E.A. Research Group Establishments at Harwell (Berks) and at Winfrith (Dorset), to undertake environmental field surveys and the radio-chemical analysis (for specific radioisotopes) of biological materials and, possibly, to investigate the application to this work of instrumental techniques, for example, gamma spectrometry—The Group Recruitment Officer (1264/34), Atomic Energy Research Establishment, Harwell, Berks.

ENGINEER (with at least three years practical experience and experience in one of the following fields: electromechanical design or estimating and contract work), to be concerned with all phases of the design, construction and operation of a 200-MeV. Heavy Ion Linear Accelerator—Prof. S. Devons, Department of Physics, The University, Manchester.

LECTURER (graduate, preferably with teaching, industrial and/or research experience) IN CHEMISTRY at the Mid-Cheshire College of Further Education, Hartford, Northwich, for at least one branch of chemistry to H.N.C. or higher level—The Director of Education, County Hall, Chester.

PHYSICAL CHEMIST (with at least two years experience in post-graduate research or in industry), to assist with teaching of applied chemistry to students of chemical engineering and to conduct research in applied physical chemistry—Dr. R. F. Strickland-Constable, Imperial College of Science and Technology, London, S.W.7.

RESEARCH ASSISTANT (with a sound knowledge of electronics and an interest in radio propagation problems) IN THE DEPARTMENT OF PHYSICS, for work in radio observation of artificial satellites—The Registrar, University College of Wales, Aberystwyth.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

National Central Library. 42nd Annual Report of the Executive Committee for the year ending 28 February 1958. Pp. 18. (London: National Central Library, 1958.) [710

British Museum (Natural History). Great Barrier Reef Expedition, 1928–29. Scientific Reports. Vol. 6, No. 6: Foraminifera. By A. C. Collins. Pp. 335–436+5 plates. (London: British Museum (Natural History), 1958.) 40*s*. [710

A Survey of Commonwealth Parliamentary Opinion on British Participation in a Free Trade Area. Pp. i+18. (London: Federal Union, 1958.) 5*s*. [710

The Changing World of the Extraction Metallurgist. By Prof. F. D. Richardson. (Inaugural lecture delivered 18 February, 1958.) Pp. 23. (London: Imperial College of Science and Technology, 1958.) 5*s*. [710

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Third Report from the Committee of Public Accounts, Session 1957–58. Pp. 32. (House of Commons Paper 256.) (London: H.M. Stationery Office, 1958.) 1*s*. 6*d*. net. [710

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Ministry of Supply. Reports on Plastics in the Tropics, No. 9: Phenolic Resin Bonded Paper Tube. Pp. 31. (London: H.M. Stationery Office, 1958.) 3*s*. 6*d*. net. [710

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Other Countries

Conseil Permanent International pour l'Exploration de la Mer, Charlottenlund Slot, Danemark. Bulletin Statistique des Pêches Maritimes, Vol. 41 pour l'Année 1956. Redige par Arni Fridriksson. Pp. xii+53. (Copenhague: Andr. Fred Høst & Fils, 1958.) Kr. 9.00. [710

Pennsylvania State University. Mineral Industries Experimental Station Circular No. 51: Selected Electron Micrographs of Clays and other Fine-Grained Minerals. By Prof. Thomas F. Bates. (Final Report on the Investigation of Morphology, Origin, and Structure of Fine-Grained Minerals.) Pp. vi+61. (University Park, Pennsylvania: M.I. Experimental Station, Pennsylvania State University, 1958.) [710

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United States Department of the Interior: Geological Surve Water-Supply Paper 1427: Geology and Ground Water in the San Rosa and Petaluma Valley Areas, Sonoma County, California. G. T. Cardwell. Pp. vii+273+8 plates. n.p. Water-Supply Pap 1433: Surface Water Supply of the United States, 1956. Part 2- South Atlantic Slope Basins, James River to Savannah River. P pared under the direction of J. V. B. Wells. Pp. viii+341. 1.25 dolla Water-Supply Paper 1434: Surface Water Supply of the United Stat 1956. Part 2-B: South Atlantic Slope and Eastern Gulf of Mex Basins, Ogeechee River to Pearl River. Prepared under the directi of J. V. B. Wells. Pp. x+380. 1.25 dollars. Water-Supply Pa 1439: Surface Water Supply of the United States, 1956. Part 6- Missouri River Basin above Sioux City, Iowa. Prepared under t direction of J. V. B. Wells. Pp. x+413. 1.50 dollars. Water-Sup Paper 1440: Surface Water Supply of the United States, 19 Part 6-B: Missouri River Basin below Sioux City, Iowa. Prepa under the direction of J. V. B. Wells. Pp. xi+487. n.p. Wat Supply Paper 1441: Surface Water Supply of the United States, 19 Part 7: Lower Mississippi Basin. Prepared under the direction J. V. B. Wells. Pp. xi+503. 1.75 dollars. Water-Supply Paper 144 Surface Water Supply of the United States, 1956. Part 8: Weste Gulf of Mexico Basins. Prepared under the direction of J. V. B. We Pp. x+423. Water-Supply Paper 1443: Surface Water Supply of t United States, 1956. Part 9: Colorado River Basin. Prepared und the direction of J. V. B. Wells. Pp. xi+466. 1.50 dollars. (Washin ton, D.C.: Government Printing Office, 1958.) [14

United States Department of Agriculture. Agricultural Informat Bulletin No. 190: Salt Problems in Irrigated Soils. Pp. 12. (Washin ton, D.C.: Government Printing Office, 1958.) 10 cents. [14

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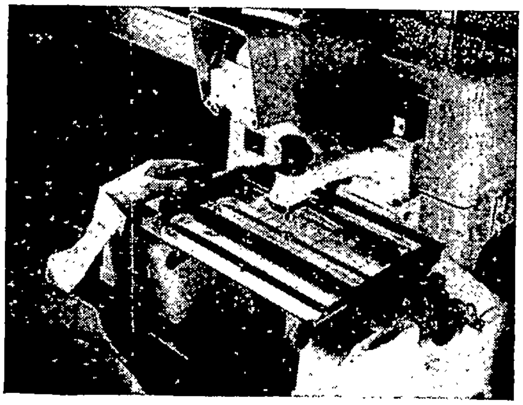

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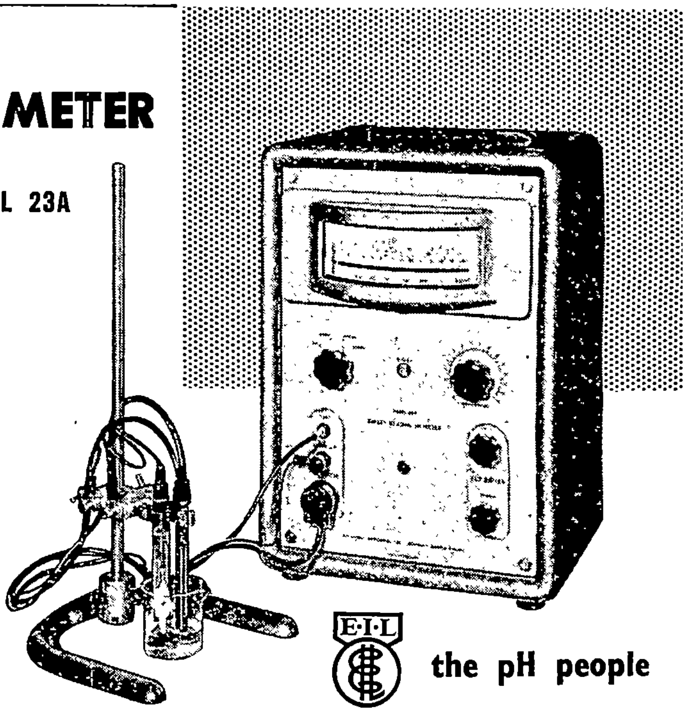

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MUTUAL ASSISTANCE BETWEEN COMMONWEALTH COUNTRIES

THE Commonwealth Trade and Economic Conference which met in Montreal during September 15–26 is of interest to scientists and technologists on several counts, not all of which are apparent from the brief report of the Conference which has been issued as a White Paper*. Telecommunications, though specialized, is a subject of obvious interest, and here the Conference agreed, in principle, on the basis of a recent report by the Commonwealth Telecommunications Board, that a round-the-world Commonwealth coaxial-cable telephone system should be constructed. If laid link-by-link the whole enterprise would probably take some ten years to complete, and might cost £88 million. Many technical problems remained to be solved, however, and apart from the financial questions still to be discussed, the Conference made no attempt to reach detailed or binding commitments.

This new enterprise, which has recently become technically possible, is expected, like earlier systems of communication, to strengthen Commonwealth associations and promote Commonwealth trade, and thus illustrates the way in which technology and science can assist the economic advance of peoples, in this case, the members of the British Commonwealth of Nations. That is notably true of research, and it is surprising that the report makes no mention of the announcement at Montreal by the United Kingdom Government that it is considering a proposal to establish, under the general control of a committee of the Privy Council, an Overseas Research Council, which would be concerned with research, particularly in the Commonwealth (*Nature* of November 22, p. 1413). In referring to this announcement, in a speech at Abingdon on October 20, the Lord President of the Council said that our existing organizations in industrial, medical and agricultural science would be made available to give assistance through the medium of this new body; this is an indication of the importance which the Government attaches to international research and follows on a powerful plea recently made by Mr. R. E. Casey, the Australian Minister for External Affairs (*Nature* of November 22, p. 1397), and further details will be awaited with interest.

At first sight it would appear that some care must be taken to avoid duplicating the work which is already being done through the Colonial Research Council, the Colonial Products Council, the Colonial Medical Research Committee, the Committee for Colonial Agricultural, Animal Health and Forestry Research and other bodies. The new body will obviously have a wider scope, so it may be presumed that before it begins to function a sufficiently clear indication will be given of its proposed relations to these bodies, so that informed criticism can be brought to bear before and not after duplication or waste of effort has occurred. It should be a prime purpose of any new organization to improve the means of communication so as to ensure that the most effective use is made of existing resources and information, and to avoid any diversion of the Commonwealth's severely limited resources of scientific and technical man-power into unproductive occupations.

It is obvious from the report that one purpose of the Montreal Conference in adopting these proposals is to enable the more prosperous members of the Commonwealth to contribute more effectively to the rapid advance of the less-developed countries. It is apparent from the latest report of the Consultative Committee of the Colombo Plan (p. 1718 of this issue) that there is increasingly general recognition that this is a matter for close collaboration between all Commonwealth countries and that the benefits are not all one way. The report emphasizes that it is of the utmost importance that the less-developed countries of the Commonwealth should succeed in implementing their development programmes, and the Conference agreed that, even to the extent of some sacrifice, all that is possible must be done to assist in the solution of these vital problems.

This problem of development, including technical assistance, is discussed at some length in a section of the report devoted to development, although in other sections also some measures intended to assist development, directly and indirectly, are indicated. The Conference recognized the importance of a broad joint effort on the part of Commonwealth countries to enable economic development to proceed as rapidly as possible in its under-developed countries, and it is seriously considered whether such development would be assisted by setting up a new institution such as a Commonwealth Development Bank. Methods of mobilizing resources for Commonwealth development are to be studied further; and meanwhile, although it was agreed that the present flexible and informal machinery for consultation is working well and is well-fitted to the character of the Commonwealth relationship, it was decided to co-ordinate these existing arrangements under the name of a Commonwealth Economic Consultative Committee. An offer by the United Kingdom Government to provide a Commonwealth House, to be available for the constituent bodies of the Council and for other Commonwealth meetings, was welcomed.

Possibly of even greater interest to the scientist than the announcement of the establishment of an Overseas Research Council, and certainly of equal importance, is the agreement of the Conference both to establish a new scheme of Commonwealth scholarships and fellowships, and to convene a meeting early in 1959 to work out details of the new scheme, and also to consider what might be done to expand and improve mutual assistance between Commonwealth countries. Even from the point of view of technical assistance, the section on education is one of the most interesting and important in the report; but it is no less vital in regard to the problem of expansion and utilization of the Commonwealth's resources of trained man-power, upon which economic advance and indeed scarcity and prosperity depend in the United Kingdom and also elsewhere.

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* Report of the Commonwealth Trade and Economic Conference. Pp. 17. (Cmnd. 539.) (London: H.M. Stationery Office, 1958.) 1s. net.

This view found wide support in the debate in the House of Lords on November 4 in reply to the Queen's speech. Baroness Elliot of Harwood, quoting the reference in that speech to the increasing association of peoples with the management of their own affairs, urged that education is fundamental, and is no less essential to the successful working of free democracy than to enable Britain to play a leading part in the twentieth-century world. Lord Soulbury, in particular, elaborated the theme, referring to the magnitude of the task of educating the multitudes of newly enfranchised electors in the countries which have become independent in the past decade, so that they should have some capacity for discrimination and criticism. Although social services such as education are the responsibility of these new independent governments themselves, the older countries could help by providing money, as through the Colonial Development and Welfare Fund, which up to last year had provided £36 million for this purpose, but still more by providing teachers.

All delegations at the Conference were agreed on the great importance of education and training as an indispensable condition of development, and the Commonwealth countries were manifestly resolved to help one another as much as possible in this field at all levels. In some countries, as Lord Soulbury indicated, the most pressing need at present is for primary education, for more teachers and for help in training them. Accelerated programmes to train foremen and technicians are also needed, as well as for new technical and other training institutions. Many of the universities in the Commonwealth would benefit from having the services for a few years of teachers from older institutions, and from being able to send to them some of the younger members of their staffs to serve temporarily as teachers. Apart from its educational value, this greater mobility and interchange would be of considerable value in the communication of ideas and the stimulation of research, and an increase in the number of scholarships and fellowships for tenure abroad and open to both undergraduate and postgraduate students would also help in that way, and in maintaining high standards of advanced study.

Much is already being done in this respect, apart from such special programmes as the Colombo Plan. More than 50,000 overseas students are already receiving instruction in Commonwealth countries—most of them from other Commonwealth countries—while there is a substantial flow of teachers and experts within the Commonwealth, and a large expansion in these facilities was already in prospect when the Conference met. The decision in principle to establish a new scheme of Commonwealth scholarships and fellowships was taken with the view of meeting the ever-increasing need for people equipped with general training to serve in all the varied processes of a complex society. Some of the new scholarships will be in the field of the humanities and the social sciences as well as the natural sciences, and will be designed to recognize and promote high standards of intellectual achievement, and others may be at various levels in the teaching field.

Within a few years of its inception, the programme is expected to cover some thousand scholars and fellows, of which the United Kingdom undertook to be responsible for one-half and Canada for one-quarter, while the Australian delegation has meanwhile announced an increase of 150 in the number of places made available for trainees under the technical co-operation programme of the Colombo Plan. The exact scope and detailed arrangements of the whole programme will be worked out after consultation with university and other educational authorities in Commonwealth countries at a meeting to be held in the United Kingdom early in 1959. The composition of this meeting remains to be determined. The meeting will also be asked to review existing arrangements for co-operation between Commonwealth countries in the field of education and to make recommendations for any improvement or expansion that may be possible, particularly in regard to the supply and training of teachers.

In welcoming the announcement of this new fellowship and scholarship scheme, Baroness Elliot hoped that it would be possible to make such scholarships available to all types of boys and girls and not only to those who might go to university and school staffs. She suggested that some exchanges might be made on the lines of those arranged very successfully by the National Federation of Young Farmers' Clubs and by the English Speaking Union. Lord Soulbury commented on the need to ensure that those seconded for educational service abroad should be assisted to obtain suitable posts on their return to Britain, and should not find that their professional prospects had suffered; and he referred also to the importance of the technician, in agriculture as well as in industry, and the bearing of elementary education on the effective use of the technical expert.

These are all particular facets or details of the whole problem, to which no doubt due attention will be given by the conference when it meets; and it may well be found that there is enough continuing work for it to develop, as Lord Soulbury suggested, into a permanent Commonwealth Council of Education, replacing the Imperial Education Committee which lapsed about 1930. Existing arrangements for educational interchange have grown up over a long period of years, and while there may be real advantages in their being in many hands, it may be useful to have some permanent co-ordinating or advisory body even if no adjustments are necessary to make the existing arrangements correspond more closely to present needs. The broad subject has already engaged the attention of the Home Universities Conference, which in December 1957 discussed the subject of academic mobility at some length.

The proposed conference should certainly consider this in the slightly wider context of professional mobility in general. From what was said at the Home Universities' Conference in 1957, it seems likely that overseas representatives will ensure that due attention is given to some of the points, such as pensions schemes, where government action should be a decisive factor in removing some of the existing obstacles to mobility. That, of course, is one matter in which the British Government representatives should be ready to concert action; but in the meantime it is to be hoped that Dr. B. V. Bowden's plea for serious study of the technical aspects of the problem is receiving attention. Indeed, one of the most important tasks to be attempted before the conference meets is to ensure that the question of scholarships and fellowships is put in its proper perspective in relation to the training and supply of men and women of high ability, and the way in which their services can be most effectively used throughout the Commonwealth.

Attention to such factors as conditions of service may help to ease one aspect that has caused some concern in Britain, apart from putting such careers in a truer perspective. The third report of the Migration Board, to which the Earl of Albemarle directed attention in the House of Lords on November 20, has referred to an increased loss of skilled and professional workers, in terms of absolute numbers, with the upward trend of emigration, as the broad conclusions drawn from the Board's study of the statistics for 1956, while the dominating feature of United Kingdom emigration in 1957 was the exceptionally heavy flow to Canada. The Board, however, did not find any cause for present concern, and in a written reply to a question in the House of Commons on November 4, the Minister of Labour, Mr. Ian Macleod, claimed that the Civil Service Commission had reported that recruitment of British scientists in the United States and Canada for research fellowships had shown encouraging results.

Nevertheless, Sir John Cockcroft, speaking in Manchester on that day, expressed the fear that too many of the best of Britain's young scientists and future leaders would be attracted overseas by the better facilities and salaries which would result from the present expansion of basic scientific research. Sir John was pleading in this connexion for the more liberal endowment of university research with equipment and assistance. He suggested, in particular, that an increase of even 1 per cent in expenditure on research and development in this direction would pay handsome dividends and greatly help to maintain our position in the world.

However, it is not simply the aspect of salaries and the actual level of scholarships and fellowships that needs to be considered if the new scheme is to have its full effect. The availability of equipment for research and teaching, the ancillary facilities, whether technicians or even clerical staff, the provision of adequate library facilities, and questions of publication and conditions of service are all important; they bear no less on the efficient use of our limited resources of trained man-power than they do on its mobility, and on our capacity to ensure that the flow is in both directions, with all that is implied in this not merely for Britain but also for the whole Commonwealth. It was rightly said in the debates in Parliament that the new scheme represents a great challenge. It is a challenge not merely to teachers and educational authorities of the Commonwealth but also—perhaps especially—to scientists and technologists of the Commonwealth, to see that the issues raised are considered imaginatively and constructively. Full use must be made of an unrivalled opportunity to remove some of the existing obstacles to the utilization of scientific work and to promote an interchange of people and thought which will prove increasingly fruitful.

NUMERICAL METHODS IN FUNCTION-SPACE

The Hypercircle in Mathematical Physics

A Method for the Approximate Solution of Boundary Value Problems. By Prof. J. L. Synge. Pp. xii+424. (Cambridge: At the University Press, 1957.) 70*s*. net.

PROF. SYNGE'S well-produced book provides a fascinating description of methods which he, with Prof. Prager, evolved to solve certain boundary value problems. It begins with a description of the geometry of function-space, and the claim that no specialized mathematical knowledge is required of the reader is for once true. The account of the properties of function-space theory in the first half of the book is not only clear and easy to read but also possesses an attractive style which makes the book difficult to put down once one has started to read it. What may well be fresh and unusual concepts to many readers are introduced so naturally, in small doses, that initial apprehensions are soon forgotten and one becomes eager only for more.

To find the solution to a boundary value problem requires the determination of the unique function which is common to the set of all functions satisfying the governing differential equation and to the set satisfying the boundary conditions; in the language of function-space, we have to find the unique point of intersection of two linear subspaces of infinite dimensionality. It is easy to build up within each of these subspaces constituent parts which are of finite dimensionality. These parts are themselves subspaces, which in general cannot be expected to intersect, but the common perpendicular of which is readily defined. It is proved that the unique point of intersection of the subspaces of infinite dimensionality lies on the hypercircle (the intersection of a hypersphere with a hyperplane) for which the shortest distance between the subspaces of finite dimensionality is a diameter. If the radius of the hypercircle is small then its centre is an approximation to the required point of intersection. Certain inequalities are also proved relating to the Dirichlet integral (that is, in the torsion problem, to the torsional rigidity).

Prof. Synge illustrates the methods particularly by reference to the torsion problem. The theory of function-space is his means to attain the end of solving this and other problems within a known degree of approximation. His description of the means is so delightful that it is disappointing to find the numerical results in the end not so satisfying. The set of algebraic equations which has to be solved to determine the shortest distance between the subspaces of finite dimensionality, in the solution of a torsion problem, are closely similar to the set which is presented in the standard method using finite-difference approximations; but the values of the stress function which these equations yield, in the torsion of a hollow square (Fig. 4.58*a*), are suspect in that even their second differences are sufficient to show a marked lack of smoothness. Furthermore, the numerical assessment of the torsional rigidity, although placed between bounds, is, on the evidence also of results for the torsion of a hollow square, no better than, if indeed as good as, that derived from the simplest finite-difference approximations.

The book is stimulating, and valuable in that it offers a novel approach to the numerical solution of boundary value problems; one looks forward to further developments of its methods.

D. N. de G. Allen

SHIPS IN ROUGH WATERS

Ships in Rough Water

By J. L. Kent. (Nelson's Nautical Series.) Pp. xiv+287. (London: Thomas Nelson and Sons, Ltd., 1958.) 32*s*. 6*d*. net.

AFTER devoting the whole of his professional career to the study of the performance of ships, Mr. J. L. Kent has written a book on a subject in which he is exceptionally well qualified. During his many years' experience of testing model ships, and research at the National Physical Laboratory, Mr. Kent not only attended numerous ship-trials under generally favourable conditions but also made ocean voyages on ships of various types with the express purpose of studying their behaviour in the varied and difficult conditions in which they normally operate.

This book is based on these experiences. It also contains a survey of theory and practice relating to the movement of sea and ships. There are three parts dealing respectively with ocean weather; behaviour of ships in a seaway; and resistance and propulsion of ships in rough water. Each part contains numerous references to relevant papers which have appeared over many years and the technical discussion is well illustrated. It is evident that the author has thoroughly searched the literature on his subject. The sub-division of the text is excellent. It is difficult to find any aspect of the performance of ships at sea which is not discussed, yet each is dealt with compactly so that the book is not unduly long. The outcome is a volume which is sufficiently technical to be of value to the owner, the designer and the student of ships, while it is written in language which is simple, direct and lucid so that it may be enjoyed by all who have a knowledge of and a love for the sea and ships.

The author is revealed as a person of exceptional powers of observation and acute memory for detail. Wherever possible he gives suggested explanations fo phenomena observed which appear to require explaining. The critical reader may not always find himself i agreement with the explanations offered, but will b impressed by the exhaustive treatment and the ver real effort to apply the knowledge gained to th improvement of the design of ships in relation to thei behaviour at sea. The final chapter is devoted t summarizing the author's conclusions, and is noteworthy for its conciseness.

In recent years the attention of the tank experimenter has been given more and more to the investigation of the sea-keeping qualities of ships, and thi change of emphasis from that on performance i smooth water is continuing. Mr. Kent does not refe specifically to this trend nor to the results of the mor recent investigations into ocean weather and performance of ships at sea. However, this is not detrimenta to the book, which is mainly a record of Mr. Kent' own experiences and ideas with supporting theor and experiment data, and in the preface he modestl indicates the need for greater knowledge. The worl of naval architecture is indebted to Mr. Kent for putting into a single very readable volume his considere views on the design of ships for service conditions, n doubt matured by leisurely reflexion in retirement.

GEOGRAPHICAL ANALYSIS OF BRITISH WEATHER

British Weather in Maps

By James A. Taylor and R. A. Yates. Pp. xiv+256 (London: Macmillan and Co., Ltd.; New York St. Martin's Press, Inc., 1958.) 21*s*. net.

THIS is an attractively produced book the eleganc of which does great credit to its printers and publishers. The authors, who lecture in the Departmen of Geography at Aberystwyth, define their purpos (p. 39): "the interpretation of the Daily Weathe Report for the non-meteorologist and in particular o (*sic*) the geographer"; elsewhere, "a method o geographical analysis and interpretation of th primary documents of British weather". Introductory chapters discuss fundamentals of Britis weather, the compilation of the Daily Weathe Report, and the prevailing characteristics of ai masses. Thereafter the method is to present well-chosen examples of representative situations, and the to plot weather elements separately and examin their distribution. Upper-air data are mentioned but stress is on the surface map.

The authors' approach is original, and without doub this compilation is useful, although it will mee with some criticism from both geographers an meteorologists. Geographers will note the difficultie arising from plotting temperature using 6-hr. dat and from the omission of upland stations (cf. p. 198) After reading p. 66 the student will be much puzzle by events at Benbecula and Tiree on Fig. 37; and (p. 90) the weather at Dishforth (Fig. 40) is scarcely anomalous under the conditions given. To a geographer, Cape Wrath is not in the Hebrides (p. 207) and West Freugh is not in the Southern Upland (p. 96). Meteorologists will not care much for th method and will find their own points to criticize for example, on pp. 55 and 63 relative and absolut humidity are confused; "the slower rate of cooling at coastal stations" (p. 190) is not well supported by Fig. 70. Noon observations would have made for better discussion; the transitional character of most of our air might have been emphasized more.

There are, however, many admirable diagrams and maps to enliven the reader; for example, those showing visibility (cf. p. 211), cloud and pressure tendency; and while alert-minded students may here and there ask awkward questions, it is good for geographers to be reminded of orographic depressions. Hence, the book will go far to fulfil its purpose; any student who works through this book will gain considerable insight into synoptic meteorology, and will be well equipped to add to his knowledge of British hill weather from other sources. GORDON MANLEY

INDUSTRY AND THE WORKER

The First Principles of Industrial Relations

By Dr. A. E. C. Hare. Pp. vii+146. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 12*s*. 6*d*. net.

Productivity and Economic Incentives

By J. P. Davison, P. Sargant Florence, Barbara Gray and N. S. Ross. Pp. 306. (London: George Allen and Unwin, Ltd., 1958.) 35*s*. net.

AN economist, Dr. A. E. C. Hare, of the University of Leeds, has written a book on industrial relations which may well become a little classic. Using knowledge gained from the study of economics, psychology, sociology and law in his quest to find the source of industrial discontents, his book ranges over the whole structure of society, its social organizations and political forms, its religious and ethical norms and its attitudes to property and work. Yet all the time Hare is concerned with those features of industrial relations which make for workers proud of their callings, satisfied with their rewards, and secure in the knowledge that they belong to efficient firms with executives who genuinely believe that good profits and sound industrial relations go hand-in-hand.

Dr. Hare shows, for example, that the common attitude of connecting the development of good industrial relations simply with the avoidance of strikes is a negative approach which begs many questions and leads to more and more industrial unrest. The study of industrial relations should take full account of the assumptions fundamental in the structure of society; the freedom of the individual in thought and speech and of his right to organize with groups of like-minded people for religious, political or economic purposes; the freedom of the individual to buy and sell and to enter any occupation he chooses; the freedom for a man to strive to increase his income and to acquire wealth and so lift his status in the eyes of his fellow-men; the right of a man to acquire and own property and to dispose of it as he pleases. These are fundamental freedoms which give rise to conflicts between themselves; freedom in one direction may have to be restricted in order to permit freedom in another. "The conflicts which arise in industry are the products of a conflict between individuals or groups, each pursuing their economic freedom to increase their income. They also arise from the conflict between the freedom to own and direct how the instruments of production shall be used and the economic freedom to work at any occupation or indeed to work at all. Freedom to direct how the means of production shall be used carries with it economic control over the lives of men and must therefore necessarily conflict not only with their economic freedom but also with many other individual freedoms."

Here lies the root of the problems of industrial relations and, in this masterly little book, which is a model of clear thinking, Hare shows how the State, the employer and the trade unions each have a contribution to make in the never-ceasing struggle to establish industrial harmony. He is wise enough to show that there are no quick or easy remedies based on the latest device.

In his analysis Hare does not minimize the part played by wages as a major cause of industrial discontent; more disputes arise in industry over wages than any other subject. Yet, as the authors of "Productivity and Economic Incentives" show, surprisingly little attention has been paid to the real effects of the economic motive in industry. Industry ceases to be unless it can produce efficiently, but even to-day there is little knowledge of how productivity is affected by the introduction of financial incentive schemes. This has been partly due to the difficulty of obtaining clear cases of an incentive applied in isolation, and partly to the neglect of the subject by psychologists. They have been, as Sargant Florence writes, "only slightly interested in tracing the economic motive or observing the material, economic facts of output, costs, absence and labour turnover".

This composite book has been written by four authors, all members of the Faculty of Commerce and Social Science at the University of Birmingham. The background is described by Prof. Sargant Florence, while J. P. Davison, after measuring their output and earnings, interviewed factory workers to determine their reaction to incentive payment schemes and ancillary matters. These accounts are supplemented by Dr. H. S. Ross, himself a former convener of factory shop stewards, who also supplies a detailed and over-long case-study of trades union and labour reactions to the application of incentives and the industrial relations background in a chosen factory. Dr. Barbara Gray interviewed and obtained the output earnings of laundry workers and shop assistants.

The conclusions of all four investigators were unanimous and clear. The introduction of financial incentive schemes in industry and commerce leads to a considerable increase in the productivity of labour together with an increase in earnings without the workers complaining of undue strain. Few there would be with knowledge of industry who would question the findings of these well-conceived and well-conducted inquiries. Few would argue against their considerable extension.

How, therefore, can their findings be reconciled with the actions of several leading British firms which, during the past few years, have abandoned their piece-work incentive schemes?

It is perhaps significant that those who are advocating the abolition of financial incentive payment schemes are those employed by companies which were among the first to introduce these schemes several decades ago and where they had reached a considerable degree of complexity. The reconciliation of this view—which has led to the abolition of financial incentive schemes in such companies as Ford and Vauxhall—and that put forward by the authors of the book may be due to two reasons. The first is that all factories striving to be efficient must introduce some kind of incentive scheme to determine its optimum rate of output; it is difficult to see how a norm can be established in any other way. The second is that the apparent success of changing from a flat rate of pay system to an incentive scheme or vice versa may be due not to the system of payment at all but to the change; it will be interesting to see whether in a few years time a new management at Ford or Vauxhall may decide the time has come for a change and revert to an incentive system of payment but worked out on lines different from those which formerly prevailed. T. H. HAWKINS

LIBRARIES FOR RESEARCH

Classification and Indexing in Science

By B. C. Vickery. Pp. xvii + 185. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 25*s.*; 5.50 dollars.

IN a recent address in Manchester to the Reference and Special Libraries Section of the Library Association, Mr. D. J. Foskett said that it was intolerable that existing discords between the general classification system and the requirements of modern research should be allowed to continue, and urged the need to adopt new systems as they become necessary so that the results of research can be organized in a way that permits of their effective retrieval. Mr. B. C. Vickery's book, to which Mr. Foskett contributes an introduction, is intended as a contribution to that end. It does not purport to be a manual of classification and indexing but is intended rather to assist those who are concerned with the practical task of constructing systems for retrieving information, whether their concern is limited to classification and indexing or also embraces mechanical selection.

As such this book is primarily a study of method. It considers, step by step, the problems which arise in constructing a faceted classification and then discusses in some detail notational devices which may be used in a classified catalogue. A further chapter considers the new developments in the use of mechanical methods of retrieving information, and discusses the limitations of conventional systems of classification and indexing for this purpose, as well as the capacities of the machines. Due weight is given to the cost aspect, and the reader who follows Mr. Vickery's counsel will not prescribe a sledge-hammer to crush a nut. Finally, after a chapter in which indexing is considered from various points of view, particularly the use of facet analysis to overcome defects in alphabetical indexing, the future trends in information retrieval are briefly outlined, and some of the areas in which further study is required are indicated.

All this is competently and modestly done with no attempt to dogmatize. But the book has a much wider interest than for the specialist. In an opening chapter on the need for classification, Mr. Vickery amplifies the thesis that all forms of information retrieval can and should be based upon a classification of knowledge if they are to function with maximum effectiveness. With the needs of the user firmly in mind, Mr. Vickery sets forth very clearly the difficulties and problems that arise and his exposition should be of real interest to any scientist who is concerned with the problem of indexing and classification in his own particular field. For the most part this is done with admirable lucidity, but for the general reader the explanation of the technique of facet analysis could be clearer, and in view of the general interest of this chapter, Mr. Vickery might with advantage amplify it in a future edition. Also of general interest are the appendix on historical aspects of the classification of science and that giving a theoretical analysis of some general catagories useful in the classification of science. A series of admirable bibliographies enhances the value of the various chapters. R. BRIGHTMAN

TREE PHYSIOLOGY

The Physiology of Forest Trees

A Symposium held at the Harvard Forest, April, 1957. Edited by Prof. Kenneth V. Thimann, with the assistance of William B. Critchfield and Martin H. Zimmermann. Pp. xvi + 678. (New York: The Ronald Press Company, 1958.) 12 dollars.

THE study of tree physiology as a separate branch of plant physiology has been traditionally confined largely to those problems of flow of sap, translocation and growth which assume particular significance in large woody perennials. In recent years, however, interest in the physiology of forest tree species at all stages of growth has grown considerably; besides a rapidly expanding fundamental research programme in forestry, many pure botanists have realized that here is a field which has been relatively little investigated in the light of modern physiological knowledge and techniques. The result has been an impressive expansion of our knowledge concerning tree growth which, until recently, has found little opportunity for collective expression. It was therefore a timely decision on the part of the Cabot Foundation for Botanical Research to arrange this the first international symposium on tree physiology. The publication of the thirty-five papers presented by invited participants provides a wealth of up-to-date information on a variety of topics, covering water relations and sap movement, photosynthesis, biochemistry, mineral nutrition, phloem transport, root growth, photoperiodism, reproduction and various other growth phenomena. Full discussions included with each paper serve as a particularly valuable source of comment, criticism and speculation.

Many of the contributions are primarily of academic interest, others of considerable practical significance in their application to sylviculture and tree breeding. The contents are therefore of interest to both botanists and foresters, and to single out particular papers as being more worthy of mention than others is a difficult task. Students of the classical physiological problems will welcome Scholander's elegant approach to the solution of the air embolism problem confronting the 'cohesion theory', and the articles of Huber and of Zimmermann dealing with phloem transport and the evidence for 'mass flow'. The various papers on photoperiodic responses, despite a certain overlap, and those on factors governing seed germination are well worth reading for both their botanical and forestry interest. Forest geneticists should certainly be stimulated by the papers discussing techniques for inducing early flowering.

On the whole, the publication maintains an excellent standard both as to contents and their reproduction. Despite its wide coverage, it leaves many important problems of tree growth untouched and raises many new ones; but, in filling at least partially a long-felt gap in our knowledge as to how trees function, it deserves, and will undoubtedly receive, a welcome reception. L. LEYTON

AIR SHOWERS OF SIZE GREATER THAN 10^5 PARTICLES*

(4) THE DISTRIBUTION OF NUCLEAR-ACTIVE PARTICLES AND OF MU-MESONS

By J. A. LEHANE, Dr. D. D. MILLAR and M. H. RATHGEBER

The F.B.S. Falkiner Nuclear Research and Adolph Basser Computing Laboratories,
School of Physics†, University of Sydney

THE importance of the nuclear-active cascade in the development through the atmosphere of an extensive shower of cosmic rays is now well established, although the details of the high-energy nucleon – nucleus interactions which generate the cascade are still largely unknown. Indeed, only from observations on the extensive air showers can one hope to gain insight into such high-energy phenomena.

Among the different types of particles in an air shower the nuclear-active particles, both nucleons and π-mesons, are produced directly in these nuclear interactions. The μ-mesons are produced at one stage removed from them by the decay of π-mesons. Investigations of these components are therefore likely to be of greater value in elucidating the nature of the interactions than are investigations of the electron component, since this last is detected after many generations of the electron-photon cascades which have been initiated by the decay of neutral π-mesons.

The experiment reported in this article was carried out in the University of Sydney (40 m. above sea-level). It was designed to determine the lateral distribution of the density of nuclear-active particles (which we shall refer to as 'nucleons' hereafter, although it must be understood that charged π-mesons are included in the term) and of μ-mesons, in air showers the measured sizes of which range from 3×10^4 to 6×10^6 charged particles. The distributions were determined for distances from the shower core of up to 50 m.

The results are consistent with earlier experiments and confirm quantitatively the fact that small showers are relatively richer both in nucleons and μ-mesons than are large showers[1]. The experimental observations at sea-level are compared with similar observations made by Vavilov *et al.*[2] at an altitude of 3,860 m., and the implications of this comparison are briefly discussed. From both sets of results we obtain figures which may be compared with the theoretical calculation of Ueda and Ogita[3] for a primary energy of 10^{15} eV. and best agreement is obtained for an inelasticity of 0·3 in the nuclear collisions, meaning that only 30 per cent of the energy of the primary particle is lost to secondary particles in each collision. However, no existing theoretical calculation of the development of the mixed cascade can yet be shown to account for all the experimental results, and it is suggested that the results are now sufficient in quantity for an extended programme of theoretical computation to be worth while.

Experimental Arrangement

A penetrating-particle detector has been included in the University of Sydney's array of scintillation counters used for the detection and analysis of extensive air showers. The array and the method of analysis of the results obtained from it, whereby the size and location of the core of each shower are determined, have already been described[4].

The construction of the penetrating-particle detector is shown diagrammatically in Fig. 1. It consists of three trays, one above the other, each containing 46 Maze-type Geiger counters, of length 50 cm. and diameter 2 cm., embedded in a lead pile. Above the topmost tray is 15 cm. of lead and 1·25 cm. of iron and between the trays is 5 cm. of lead and 1·25 cm. of iron. On the bottom is a layer of lead 2·5 cm. thick. Any particle entering the side of the pile without scattering must traverse at least 15 cm. of lead in order to be detected.

Each counter is connected to its own coincidence and memory unit, a two-grid thyratron, the condition of which determines whether or not a particle has traversed the counter in coincidence with an air shower detected by the scintillator array. The stored information from all the counters in the penetrating-particle detector is punched on paper tape which may then be examined visually or analysed by the electronic computer SILLIAC.

Classification of Events

The distinction between events caused by an incident μ-meson and by a nucleon is in principle simple. A μ-meson, provided it has an energy greater than 380 MeV., will traverse all three counter trays and discharge three colinear counters, one in each tray. A nucleon, on the other hand, will interact in the lead or the iron, producing secondary particles

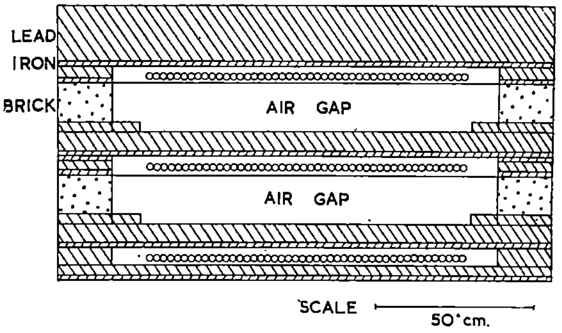

Fig. 1. Construction of the penetrating-particle detector

which will discharge several counters. The lower limit to the energy of such nucleons is not well defined by the number of counters discharged but is likely to be of the order of several GeV. (ref. 5). The electrons of the air shower are stopped by the shielding material. This classification into μ-meson, and nucleon, events is, however, liable to be affected in the following ways.

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* Preceding articles in this series appeared in *Nature*, 182, 905, 973 and 1053 (1958).

† Also supported by the Nuclear Research Foundation within the University of Sydney.

A μ-meson traversing a tray of counters may be accompanied by a knock-on electron which traverses a second counter in the tray, thereby simulating a low-energy nuclear interaction. The magnitude of this effect was determined in a subsidiary experiment in which 'straight-through' μ-mesons of the normal cosmic-ray flux which traversed the detector were selected by a counter telescope, the output from which was used to trigger the recording apparatus. The number of events in which one adjacent counter was struck, in addition to the three collinear counters traversed by the μ-meson, was found to be a fraction $0 \cdot 11 \pm 0 \cdot 01$ of the number of traversals. For the air-shower events the corresponding fraction was $0 \cdot 12 \pm 0 \cdot 02$ of the events in which three collinear counters were traversed. In view of this agreement, all events in which one counter was struck in one tray adjacent to the counters defining the trajectory of the μ-meson were classified as 'μ-meson induced'.

Because of the thickness of the walls of the counters, there exists a geometrical inefficiency for detection of particles. The subsidiary experiment mentioned above showed that there was a 10 per cent probability that a μ-meson traversing the detector would fail to traverse the sensitive volume of a counter in one of the trays, a result in agreement with the geometry of the trays. Consequently it was decided to accept as μ-meson events those in which only one counter in each of two trays was traversed, provided the supposed μ-meson trajectory was not inclined at an angle greater than about 40 deg. to the vertical. No correction was applied to the observed number of μ-mesons for those events which missed detection in more than one tray, since their number should be less than 1 per cent of the total number of observed μ-mesons.

Also omitted from the μ-meson class of events were those μ-mesons which produced knock-on showers discharging several counters and therefore were classified as nucleon events. From the subsidiary experiment mentioned earlier such events produced by the penetrating cosmic-ray flux, and which therefore included a contribution from genuine nucleons, occurred with a frequency less than 1 per cent of the μ-meson traversals. No correction has therefore been made for such events.

In selecting the events induced by the interacting nucleons, two different criteria have been used. For the first of these, the minimum requirement is that one counter be struck in at least two trays together with at least one non-adjacent counter within a distance of five counter widths. The second, more rigorous criterion, demanded that at least three counters be struck in each of two adjacent trays. These could be ascribed to higher-energy nucleon events. It is possible that in the first of these classes of events there will be a higher proportion of misclassified μ-meson events than in the second. No evidence for this has been observed, however, in comparing the lateral distributions of all nucleons, selected according to the first criterion, and of the high-energy nucleons, selected according to the second.

It is possible for a μ-meson and a nucleon to traverse the apparatus together, and frequently such events were indeed observed. However, in no single nucleon event is it possible to exclude the presence of a μ-meson traversal masked by the nucleon interaction. Rather than carry out the statistical procedure necessary to make use of such double events, the μ-meson distributions were obtained by excluding from the analysis all showers accompanied by nucleon events. It is thereby assumed that the μ-mesons and nucleons are spatially uncorrelated.

An incident nucleon may pass through the detector without undergoing any detectable interaction. The mean free path for interaction has been taken as 160 gm. cm.$^{-2}$ in lead and 130 gm. cm.$^{-2}$ in iron, and it is estimated that one-sixth of the nucleons will therefore traverse the detector without interacting. Of these, we have assumed that some 60 per cent are charged particles[6] which will be then wrongly classified as μ-mesons. In deducing the distributions of μ-mesons, 10 per cent of the corresponding nucleon density has accordingly been subtracted from that of the μ-mesons at each distance from the shower core. This correction may in fact be too small, since a non-interacting proton of energy 600 MeV. may traverse the detector simulating a μ-meson, whereas an interacting nucleon must have an energy of several GeV. to produce a detectable interaction. The true μ-meson distribution may therefore be even flatter near the shower core than we find.

Analysis of Results

A total of 3,240 showers was available for which the shower size and the location of the core were determined, the former to within limits of + 20 per cent and − 10 per cent, the latter with an uncertainty about ± 4 m. These showers were classified in 25 groups—in five ranges of shower size from 0·1 to 1, 1 to 3, 3 to 6, 6 to 10 and 10 to 60 × 10^5 particles —and in five ranges of distance of the penetrating particle detector from the shower core—from 0 to 50 m., in 10 m. intervals. For each of the 25 groups the mean shower size, N_i ($i = 1, \ldots, 5$), and the mean distance from the core, r_j ($j = 1, \ldots, 5$), were determined.

If for a class of showers, all of size N_i, the density of μ-mesons or of nucleons at a distance r_j from the core be denoted by x_{ij}, then the probability of observing m_{ij} showers in which one or more of the particles under consideration has traversed the detector, and n_{ij} showers in which no particle has traversed it, is proportional to :

$$P(m_{ij},n_{ij}) = [1 - \exp(-Ax_{ij})]^{m_{ij}} [\exp(-Ax_{ij})]^{n_{ij}}$$

where A is taken as the area of one of the trays of Geiger counters for μ-mesons, and as five-sixths of this area for nucleons, thus taking into account the probability for interaction by the nucleons discussed above.

Using the values of m_{ij} and n_{ij} determined experimentally, this probability function was computed, as a function of the variable x, for each of the 25 groups of showers and the probability distributions were drawn. From these were determined the median values of x and the quartile values.

In Figs. 2 and 3 are plotted the median values of x_{ij} in particles per square metre divided by N_i, the mean shower size, as a function of r_j in metres. The error limits shown are typical for all points and correspond to the quartile value of the distributions

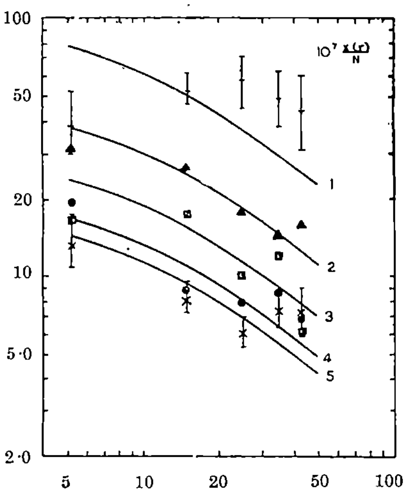

Fig. 2

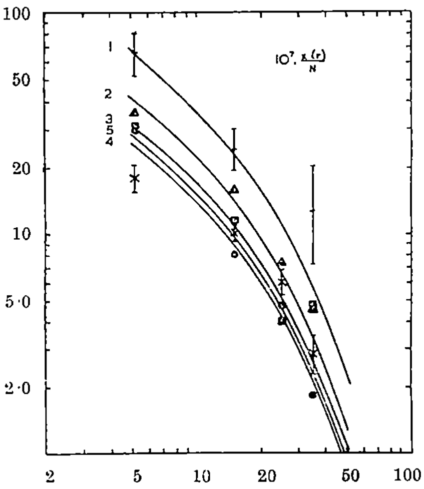

Fig. 3

Fig. 2. Density of μ-mesons $x(r)$ in particles/m.^{2} divided by the mean shower size in scintillator particles as a function of distance from the shower core r in metres. (+ denotes showers of mean size $\bar{N} = 6{\cdot}2 \times 10^4$; △, $1{\cdot}9 \times 10^5$; ▣, $4{\cdot}4 \times 10^5$; ⊙, $7{\cdot}8 \times 10^5$; ×, $1{\cdot}8 \times 10^6$)

Fig. 3. Density of nucleons shown in the same way as for μ-mesons in Fig. 2

in x. These limits then correspond to probable errors. In Fig. 2 the derived density of μ-mesons has been corrected at each distance for contamination by non-interacting charged nucleons by subtracting from it 10 per cent of the corresponding nucleon density as given in Fig. 3.

It is clear that the statistics are not yet good enough to determine whether there is a change in the shape of the functions for μ-mesons and nucleons relating x/N and r as the shower size increases. It is also clear, however, that for any fixed distance from the core the ratio x/N increases with decreasing N: small showers are relatively richer in both μ-mesons and nucleons than are large ones.

The curves which have been fitted to the points of Figs. 2 and 3 were deduced as follows. It was assumed that the density of both μ-mesons and of nucleons was expressible in the form $x(r) = N_i f(r)$. For each of the five mean distances, r_j, the expression $\prod_{i=1}^{5} P(m_{ij},n_{ij})$ was computed as a function of f, and from the probability distributions so obtained the median values and the quartile values of f were again obtained for each distance r_j. The radial distributions so obtained were plotted for μ-mesons and for nucleons. Again, 10 per cent of the nucleon ordinates were subtracted from the μ-meson ordinates at each distance. A smooth curve was drawn through these points. These curves were then fitted to the points of Figs. 2 and 3, using the computed probability distributions in x_{ij} by a maximum likelihood method.

As a second approximation it was assumed that $x(N,r) = Nk(N)f(r)$, where $k(N)$ is a slowly varying function of N, and is in fact given by the separation of the curves of Figs. 2 and 3. These values of $k(N)$ as a function of N are plotted in Figs. 4 and 5, taking in each case $k(N) = 1$ for a shower size $N = 10^6$ particles. The errors quoted on the values of $k(N)$ are probable errors derived in the curve-fitting procedure. Taking these values of $k(N_i)$ and putting $x(N_i,r_j) = N_i k(N_i) f(r_j)$, the expression $\prod_{i=1}^{5} P(m_{ij},n_{ij})$ was again computed as a function of $f(r_j)$. The probability distributions were again plotted, and median and quartile values of f determined for each r_j. These values of $f(r)$ are plotted in Figs. 4 and 5 for μ-mesons and nucleons. Again the μ-meson ordinates have been corrected by 10 per cent of the nucleon ordinates at each distance. The calculated values of $f(r)$ so obtained were consistently about 10 per cent greater than those already obtained by averaging over showers of all sizes. This similarity in shape of the distribution curves at the two levels of approximation arises from the fact that the shower-size distributions in each distance class were similar.

In Fig. 5 we have also plotted the lateral distribution function for the high-energy nucleons. Because of limited statistics only the first approximation procedure was adopted. There is no significant difference between the two distributions. The curves drawn through the nucleon points have the analytical form $f(r) = A\exp(-r/20)\ r^{-1/2}$ with $A = 7{\cdot}5 \times 10^{-6}$ for the total nucleons, 3×10^{-6} for the high-energy nucleons.

If then the density of μ-mesons and of nucleons may be expressed in the form $x(N,r) = N\,k(N)f(r)$, so that the radial part of the distribution $f(r)$ is independent of N, then the curves of Figs. 4 and 5, giving $k(N)$ as a function of N, and $f(r)$ as a function of r, define x.

Discussion

From the experimental results presented in Figs. 2 and 3 one finds that, at a distance of 5 m. from the

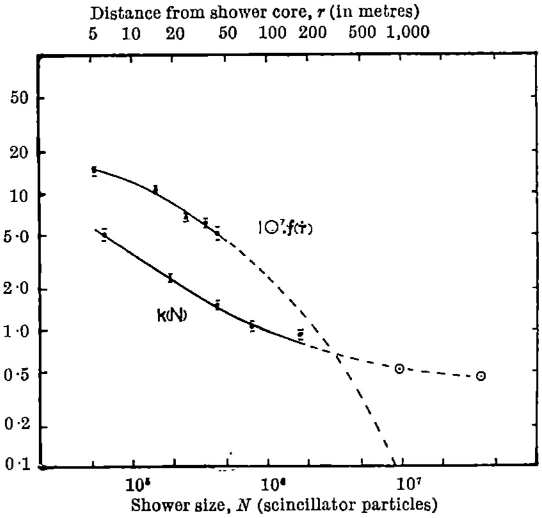

Fig. 4. Density of μ-mesons expressed as a function of shower size, N (scintillator particles), and the distance from the shower core, r, in metres. The density of μ-mesons is given by $x(N,r) = N\,k(N)f(r)$ per sq. metre. The extrapolated part of the curves are obtained from the Harwell observations

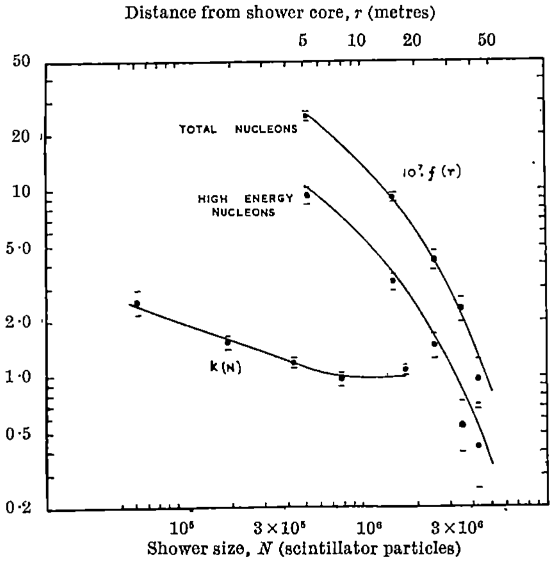

Fig. 5. Density of nucleons expressed in the same way as for the μ-mesons of Fig. 4. High-energy nucleons are those for which the minimum number of Geiger counters discharged is greater than for the total nucleons

shower core and in a shower of size 10^5 particles the density of nucleons and of μ-mesons are both $\approx 0{\cdot}5$ m.$^{-2}$. The total particle density, estimated from our shower structure function[4], is 35 m.$^{-2}$. For a 10^6-particle shower, on the other hand, the densities of nucleons, μ-mesons and total ionizing particles are respectively 3, 1·7 and 350 m.$^{-2}$. Since these nucleon densities refer to nucleons detected by our apparatus and therefore having energies greater than several GeV. (and this lower limit may be as high as 10 GeV.) we should expect a density of low-energy nucleons appreciably higher than these quoted values. Such low-energy nucleons would then constitute an appreciable fraction of the total particle density near the core and may be expected to play a significant part in determining the form of the shower-structure function of all ionizing particles near the core. Further evidence confirming the existence of a high relative density of lower-energy nucleons near the shower core has been obtained from a detailed comparison between the response of a scintillation counter and of a Geiger counter[7].

Several experiments have been carried out in the past using arrays of shielded and unshielded trays of Geiger counters in which the rate of coincidences between trays has been used to obtain an average value of the density of penetrating particles—both μ-mesons and nucleons—relative to that of all ionizing particles in the showers recorded. Such experiments at sea-level have given a value of about 2·5 per cent for the ratio of penetrating particles to total particles, a value which depends, however, upon the way in which the showers are selected[8]. The ratio of μ-mesons to nucleons has also been determined in similar experiments and found[9] to be about 2 : 1. From our results these figures can be obtained in a shower of size 10^6 particles and at a distance of 40 m. from the shower core. However, the interpretation of the average values obtained experimentally in terms of an average shower of size 10^6 particles falling with its core 40 m. away from the detecting apparatus is not particularly significant, since the shower-structure functions for μ-mesons, for nucleons, and for total particles in a shower differ from each other markedly, both in their dependence upon radial distance, r, and upon shower size, N. There appears to be no great difficulty in reconciling these earlier experiments with the results presented here.

In Fig. 4 are presented the results of Fig. 2 for the μ-meson distributions in the form $x(N,r) = N\,k(N)\,f(r)$ particles per square metre. Fig. 4 also shows the sea-level results reported by the Harwell group[10]. The extrapolated part of the $f(r)$ curve, from 40 m. to 1,000 m., is the curve for $x(r)$ given by them for showers of mean size $6{\cdot}7 \times 10^6$ particles, joined to our own at 40 m. Since they were using a Geiger counter array we have multiplied their shower size by a factor of 1·4 in order to convert it into the shower size as it would be estimated by our scintillator array[11]. The normalization of the two curves at 40 m. leads to a value of k for such a shower size of 0·52. Similarly, the value of $k(N)$ for their larger size group has been obtained from their quoted density of μ-mesons in such showers at 100 m. from the core and from the $f(r)$ value at this distance as given by the extrapolated curve of Fig. 4. The radial distributions given by the Harwell group for the two mean shower sizes do not differ in form significantly from each other.

The results from Harwell on the density distribution of nucleons is of limited statistical significance since their shower cores are located with large uncertainty. However, they do obtain an estimate of the total number of nucleons detected, from the total number of nucleon events detected in showers of mean size $6{\cdot}7 \times 10^6$ charged particles. Their estimated number is $(4 \pm 2) \times 10^4$. Integration of our analytical-structure function leads to a predicted number in such showers of $3{\cdot}8 \times 10^4\,k(N)$ of total nucleons, of which five-sixths would be observed to interact in a detector such as our own.

One may consider the data of Figs. 4 and 5 merely as a convenient way of representing the experimental observations. If, on the other hand, it is assumed that the shape of the distribution function $f(r)$ is strictly independent of shower size N then the total numbers of nucleons and of μ-mesons are proportional to $Nk(N)$. We then find from the results presented in Figs. 4 and 5 that the total number of nucleons in showers of size 6×10^4 to 8×10^5 is proportional to $N^{0\cdot6 \pm 0\cdot1}$, whereas for μ-mesons it is proportional to $N^{0\cdot4 \pm 0\cdot1}$. From the additional μ-meson data of the Harwell group there is evidence that the exponent in the relation may increase at large values of N.

Experiments very similar to our own have been carried out at an altitude of 3,860 m. in the Pamirs by Vavilov *et al.*[2], and it is of interest to compare the results obtained at the two altitudes. In showers of size less than 2×10^5 they find the number of nucleons to be proportional to $N^{0\cdot2}$ and for larger sizes it is proportional to $N^{1\cdot0}$. The change which occurs at a shower size of 2×10^5 particles they interpret as indicating a change in the nature of the high-energy interaction at an energy of 10^{15} eV., their estimate of the primary energy of such a shower. If this were so we might expect that our sea-level showers of size greater than 2×10^5 particles, initiated by higher energy primaries, would contain nucleon numbers proportional to $N^{1\cdot0}$ rather than $N^{0\cdot4}$. The interpretation given above of the results from the Pamirs is not, therefore, likely to be correct.

In comparing further the results obtained at sea-level and at mountain altitudes we may take the number of nucleons at sea-level, n_1, in a shower of size N_1 to be proportional to $N_1^{\gamma_1}$, and at mountain altitudes the corresponding numbers of nucleons, n_2,

Table 1. THEORETICAL RESULTS OF UEDA AND OGITA FOR A SHOWER OF PRIMARY ENERGY 10^{15} EV., COMPARED WITH THE CORRESPONDING EXPERIMENTAL RESULTS AT TWO ALTITUDES

$\eta =$	Sea-level, 1,030 gm. cm.$^{-2}$			Mountain altitude, 640 gm. cm.$^{-2}$		
	N	n_{nucleons}	n_{μ}	N	n_{nucleons}	n_{μ}
0·3	$3 \cdot 6 \times 10^5$	1,900	4,500	$7 \cdot 8 \times 10^5$	2,300	2,300
Experimental	$5 \cdot 0 \times 10^5$	2,100	0·65	$7 \cdot 8 \times 10^5$	2,100	0·48
0·5	$2 \cdot 4 \times 10^5$	450	7,000	$9 \cdot 7 \times 10^5$	1,800	6,000
Experimental	$3 \cdot 4 \times 10^4$	1,600	0·54	$9 \cdot 7 \times 10^5$	2,900	0·56
1·0	$1 \cdot 3 \times 10^5$	100	8,700	$1 \cdot 3 \times 10^6$	1,000	8,000
Experimental	$1 \cdot 8 \times 10^5$	1,000	0·43	$1 \cdot 3 \times 10^6$	3,900	0·74

as proportional to $N_2^{\gamma_2}$. Then if the shower size is attenuated by a factor A between these two altitudes, so that $N_2 = AN_1$, we find that the nucleons will be attenuated by a factor n_2/n_1, which is proportional to $A^{\gamma_2}N_1^{\gamma_2-\gamma_1}$. The attenuation factor, A, appears to be independent of shower size and, corresponding to constant attenuation length of 190 gm./cm.^{2} (ref. 12), is equal to 8. We find from our results that $\gamma_1 = 0 \cdot 6 \pm 0 \cdot 1$, and from the Pamirs results for the corresponding showers eight times the size of our own, that $\gamma_2 = 1 \cdot 0 \pm 0 \cdot 1$. The attenuation factor for the nucleons is thus dependent on shower size to the extent that $\gamma_2 - \gamma_1$ may be considered different from zero. Similarly, the μ-meson results indicate that the attenuation factor is again dependent upon shower size, and as for the nucleons, the μ-mesons are less attenuated in small showers than in large.

It may be unwise, however, to carry too far an argument which assumes that a given shower size at sea-level may be related uniquely to a corresponding shower size at mountain altitude, and that this in turn may be related uniquely to a corresponding energy of the primary particle. Fluctuations in the development of the air shower, together with the existence of a spectrum of energies and of masses of the air-shower primaries, may modify considerably the interpretation of the experimental data.

A further point of comparison between the mountain and the sea-level results is afforded by the forms of the distribution functions for μ-mesons and for nucleons which have been determined at the two altitudes. It has already been noted by the Harwell group that the Pamirs μ-meson distribution falls off more rapidly at large distances than does theirs. On the other hand, the structure function which we have used as a good fit to our sea-level results for nucleons may be also fitted to the experimental points for two shower sizes quoted by Vavilov *et al.* Their nucleons were detected in a similar apparatus and were selected according to the same criterion as our own. There is consequently no indication that the nucleons are spread out more at sea-level than at mountain altitude.

Lastly, the results have been compared with the theoretical predictions of Ueda and Ogita[3]. Those authors calculated the longitudinal development of a model air shower initiated by a primary particle of energy 10^{15} eV. and derived as a function of depth in the atmosphere the total numbers of electrons, μ-mesons and nucleons for different values of the inelasticity, η, of the nucleon–nucleus collisions. Table 1 gives the theoretical predictions of the total numbers of electrons, of nucleons of energies greater than 10 GeV. and of μ-mesons produced by decaying π-mesons above the same energy-limit, for different values of η. Also given are the estimates of these numbers from the experimental observations. The nucleon numbers at sea-level are those obtained by integrating our analytical expression for $f(r)$. The numbers of nucleons at mountain altitude are obtained by increasing the values quoted by Vavilov *et al.* by 30 per cent, to include a contribution from nucleons at distances greater than 50 m. The total numbers of μ-mesons have not been calculated since the contribution from large distances where the structure function is not well defined is considerable; instead we have quoted a number proportional to the density of μ-mesons at a distance of 20 m. from the core of the shower, neglecting the fact that the μ-meson distribution at mountain altitude appears to be narrower than at sea-level. If, in fact, both at sea-level and at mountain altitude, the nucleons detected in the experiments are of energy greater than 10 GeV. and the μ-mesons detected are proportional to the number which have come from π-mesons of energy greater than 10 GeV., the data are seen to be in reasonable agreement with theoretical expectation for $\eta = 0 \cdot 3$. Again, however, it should be pointed out that this one-to-one correlation between primary energy and detected shower size at two altitudes may be of doubtful validity.

Summary

We have determined the nucleon and μ-meson density distribution for showers of size 5×10^4 to 2×10^6 scintillator particles out to distances of 40 m. from the shower core. There is no significant evidence that the forms of the distribution functions change with shower size, although additional statistics will be required in order to determine whether this is really the case.

On the assumption of a constant form for the radial structure function, the number of μ-mesons in the showers recorded varies as $N^{0 \cdot 4 \pm 0 \cdot 1}$ and of nucleons, as $N^{0 \cdot 6 \pm 0 \cdot 1}$, within the range of shower sizes investigated. Comparison with similar experimental observations at mountain altitude indicates, on this assumption, that the attenuation-length of nucleons and of μ-mesons is longer in small showers than in large.

A comparison has been made with the theoretical results of Ueda and Ogita for one primary of energy 10^{15} eV. and this leads to agreement with a value of 0·3 for the inelasticity of the high-energy collisions of the nucleon cascade. An extension of the theoretical calculations, in the first instance to cover a range of the primary energy spectrum, and to include the effects of fluctuations in depth of the first collision, would probably allow a more detailed and a more meaningful comparison to be made with all the experimental data which are at present available.

Our thanks are due to Prof. H. Messel and to the Nuclear Research Foundation for the provision of the experimental facilities with which this work was carried out. It is a pleasure to acknowledge the large part played by the other members of the Air Shower Group in running the experiment and in discussion of the results. One of us (J. A. L.) has been supported in this work by a grant from the Australian Atomic Energy Commission.

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NUTRITION AND TEETH

THE Nutrition Society symposium on the relationships between nutrition and the growth and health of teeth was held at the London Hospital Medical College on October 4, when the chair was taken by Lady Mellanby. The meeting opened with a general review by Prof. F. C. Wilkinson.

The structure of teeth was dealt with by Prof. A. I. Darling, and their embryology, with particular reference to the histochemistry, by Dr. R. Ten Cate. The tooth consists largely of dentine, the material which gives it its elasticity. Whereas root dentine is covered by a thin layer of cementum, crown dentine is covered by enamel. At the centre is a cavity containing the dental pulp. The tooth is slung in its sockets by the fibres of the periodontal membrane which stretch from the bone of the alveolus to the cementum, and at its neck is an attachment between the oral mucosa and the enamel which is itself of ectodermal origin. Chemically, dentine contains about 5 per cent water, 75 per cent other inorganic constituents, mainly hydroxyapatite, and 20 per cent organic constituents[1], mainly collagen, but with small amounts of citric acid, insoluble protein, mucopolysaccharides and fat. Structurally, it is composed of a collagenous matrix which, when calcified, forms its main bulk, through which run the dentinal tubules from the pulp to the amelodentinal junction.

As the tooth develops, a series of changes occur which eventually determine the pattern of the crown, after which the dentine and enamel are elaborated. The formative cells of the dentine, the odontoblasts, are rich in carbohydrate and nucleic acid. Their precise function remains obscure, but close by is the sub-odontoblastic layer rich in alkaline phosphatase activity and with a high content of ribonucleic acid, which probably indicates protein metabolism[2]. The dentine matrix consists of a cementing substance and the so-called fibres of von Korff, which arise in the sub-odontoblastic layer and which gradually change from pre-collagen to collagen. As the matrix becomes calcified the odontoblasts retreat, leaving behind the processes which become incorporated in the tubules running through the dentine. With ageing of the tooth, these tubules close down and are eventually obliterated, perhaps by calcification within the tubule.

Mature dental enamel, consisting of approximately 0·5 per cent of organic material and 99·5 per cent of inorganic salts and water[3], is the hardest tissue in the body—about as hard as sapphire. The process of amelogenesis consists in the formation of an enamel matrix and in the calcification of the enamel. The enamel-forming cells, the ameloblasts, produce at their formative ends Tomes processes which become the pre-enamel rods into which calcium salts are precipitated. Initially, ameloblasts are rich in glycogen, which disappears as the Tomes processes are elaborated. This may represent a phosphorolytic degradation of glycogen to hexosephosphate esters utilized in the synthesis of acid mucopolysaccharide of the enamel matrix. In amelogenesis, as in dentinogenesis, the formative cells are devoid of alkaline phosphatase and yet exist close to cells rich in the enzyme where, it can be postulated, the mucopolysaccharide is made[4]. This has the property of imbibing water, and probably plays an integral part in forming the crown. Calcification starts soon after the deposition of the matrix, which consists mainly of keratin but contains some soluble protein and carbohydrate, and is probably not completed until shortly before eruption. Enamel is made up of prisms arranged in a complex manner. Soluble organic material lies between them and at their cores, while the prism sheaths are keratinous. The inorganic part of the enamel is almost certainly a hydroxyapatite, with some carbonate adsorbed on to the surface of the lattice, and trace elements such as fluorine, copper and iron actually within or also adsorbed on to the surface of the lattice. The trace elements occur almost exclusively in the surface enamel.

Cementum is very like bone, and consists of a collagenous matrix in which calcium salts are deposited. The dental pulp is the remnant of the organ forming dentine and consists mainly of connective tissue cells with a layer of odontoblasts next to the dentine. It communicates with the periodontal membrane, from which it receives its nervous, vascular and lymphatic supply. Nerve fibrils reach the pulp in large numbers and branch beneath the odontoblastic layer. From there, nerve fibrils pass into the uncalcified layer of pre-dentine and probably into the dentine[5], but not the enamel. The vascular and lymphatic supply is rich and closely related to the supply to the periodontal membrane. It seems that there are pathways from the pulp to the oral surface and to the periodontal membrane and *vice versa*, but how they are used in life for the purposes of exchange is still unknown. Exchange in dentine is probably much less than in bone, and enamel is more stable still. When enamel is impermeable the barrier is probably at the enamel surface. The precise role of nutritional factors in the formation of the different parts of teeth has not been elucidated, but it seems that if such factors are to affect the resistance of enamel to attack they must act during the formative period.

Dr. E. W. Bradford stressed that far more teeth are lost by the periodontal diseases, which affect the gum, the alveolar bone, the periodontal membrane and the cementum, than by dental caries. These are of three groups: inflammation of the gums or gingivitis; periodontitis simplex or destruction of the supporting tissues by bacteria or tartar; periodontitis complex or destruction of the tissues for no local reason. They can be considered as a battle between the invasiveness of bacteria and the accumulation of tartar, and the resistance of the periodontal tissues. The result varies greatly between individuals, for reasons almost unknown. The effect of food can be local or systemic. Locally, a high carbohydrate diet stimulates the secretion of saliva with a high water-content and rich in inorganic salts which can form tartar. The proportion of tartar which accumulates on the teeth varies with the amount of chewing, which at all ages promotes the health of the teeth. Thus the more fibrous the diet the better. Much less is known about the systemic effect of diet. In gingivitis and periodontitis simplex, dietary deficiencies are rarely the primary cause. Deficiency of vitamin C or of vitamin D and calcium can be contributory, though probably not causative, in periodontitis complex. Shortage of one or another essential amino-acid in the supporting tissue might be the decisive deficiency and is ripe for investigation.

Dental caries is the result of bacterial attack on the surface of the tooth: the point of interest is what starts the attack. Dr. R. L. Hartles and Mr. G. L. Slack described the incidence, since the beginning of the Second World War, of dental caries in Britain[6] and other countries[7], and gave as the most likely explanation of reduced incidence in war-time the reduced consumption of fermentable carbohydrate. They discussed the results of experiments on rats[8], hamsters[8] and monkeys[9] with natural and high-sugar purified diets, which suggest that such a purified diet is cariogenic and more so if fed during the development of teeth, but that the natural diet fed during development bestows some protection, probably in its mineral fraction, against subsequent exposure to the purified diet.

Dr. G. N. Jenkins also described experiments which suggest the presence of protective factors, possibly buffers, calcium and phytates in crude cane juice, black treacle and high-extraction flours. There was general agreement that the only factor which has been proved to be of value in reducing the incidence of caries in man is the fluoride ion, which makes the enamel more resistant to dissolution by acids: it may act as an enzyme poison preventing the formation of acids. Dr. Jenkins mentioned the possibility that the initial attack on enamel might be made by proteolytic bacteria and might result in decalcification at neutral or alkaline *p*H, but based his review of the environmental aspects of dental caries on the idea that the acids formed from carbohydrate by oral bacteria are the major factor in the development of caries. He described experiments[10] which lead to the conclusion that carbohydrate causes the *p*H of the dental 'plaque' to fall from 7·0 to about 5·0, and that at a critical point, varying with individuals but somewhere between 5·5 and 5·0, the ionic concentrations of the saliva are no longer able to prevent dissolution of the enamel. The more rapid the flow of saliva, the higher the *p*H and buffering power[11]. Thus, tough foods and vigorous chewing help to prevent the saliva reaching the critical *p*H; frequent carbohydrate meals[12] help to bring it there.

The general impression that sufficient protein, mineral and vitamin constituents are necessary for the formation of sound teeth, but that their health can be lost by much soft carbohydrate and insufficient chewing found some support in an archæological review by Mr. D. R. Brothwell. He took the meeting back half a million years to show that signs of dental disease had been found even among early hominid groups[13], and 15,000 years ago among Neanderthal man[14]. His conclusions were that the incidence of dental disease was low in neolithic times when teeth may have been helped by the rough nature of the food consumed, that, in general, dental health declined thereafter, and that for the population of the British Isles the causative factors were the introduction of sugar in the twelfth century and refined flour in the nineteenth. It is clear, however, that even without these adjuncts of civilization neither man nor ape was immune from dental disease.

A combined attack of dentist and dietitian on gross caries in young children was described by Mr. A. M. Horsnell and Mrs. E. Scott. While carious primary teeth can be filled, for treatment to be satisfactory the carious process must first be stopped. This has been achieved by giving dietary advice based on an assessment of the nutritional value of the diets of the patients. Dietary results showed a fairly consistent pattern of snacks between meals, low intakes of protein, calcium, and sometimes iron and some vitamins, and high consumption of carbohydrate. The advice given was to emphasize the importance of milk, vegetables and fruit, such as a raw apple, and a good breakfast containing a source of protein (to avoid the tendency for a mid-morning carbohydrate snack); that no snacks should be taken between meals and that any sweets should be eaten with meals. Dental and general health of the children can be improved when the co-operation of parents and children has been won. To the audience, somewhat bemused by the complexities of the biochemistry of dental development and destruction, this clear demonstration of the effectiveness of the most promising regimen for the protection of teeth was a joy.

The papers read at the symposium will be published in full in the first issue of Vol. 18 of the *Proceedings of the Nutrition Society*, which will appear in March 1959. D. F. Hollingsworth

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OBITUARIES

Sir Gilbert Walker, C.S.I., F.R.S.

SIR GILBERT WALKER died on November 4, some four months after his ninetieth birthday. For half a century his has been a prominent name in meteorological circles, and in recent years one was apt to forget that he had been elected a Fellow of the Royal Society for original work in dynamics and electromagnetism before ever he turned his thoughts to meteorology.

Walker went up to Trinity College, Cambridge, from St. Paul's School with a mathematical scholarship. He fully confirmed his early promise on graduating as the Senior Wrangler in the Mathematical Tripos of 1889, an achievement that was followed in due course by election to a fellowship of Trinity and then to a lectureship, both of which he held until going to India. From 1892 onwards he published a series of papers on the theory of electromagnetism, for one of which he was awarded an Adams Prize in 1900. In the same period he was showing a keen interest in dynamical problems, with papers on such subjects as the motion of elongated projectiles, dynamical tops and boomerangs, in which his interests were not wholly theoretical, for he became expert as designer and thrower of boomerangs, and indeed was known in the Cambridge of those days as 'Boomerang Walker'. It is a matter for some regret that his article on "Spiel und Sport" in the great "Encyklopädie der Mathematischer Wissenschaften" was never well known to his own compatriots.

Walker went to India in 1903 to succeed Sir John Eliot as director-general of observatories. The great Indian famine of 1899–1900 was still very much in people's minds and, as it were, challenged Walker to attempt to solve the very complex and difficult problem of forecasting the monsoon rainfall. The physical causes that produce the fluctuations from year to year defied and still defy detection. Walker decided to apply the statistical methods of correlation and soon made the subject of seasonal 'foreshadowing' by these methods peculiarly his own. His investigations, beginning with the search for relationships between previous weather over different parts of the globe and the Indian monsoon rainfall, developed into an examination of the interrelations of world-wide variations of weather, contemporary and consecutive. His papers are a mine of statistical information on world weather, interspersed with concise, critical and acute comment. Of the more important generalizations that emerged, there was one that he called the Southern Oscillation, which may be described as a tendency for air to disperse from the Pacific area at the same time as air accumulates in and around the Indian Ocean. The monsoon plays a part in the Southern Oscillation, out of the elements of which he evolved a formula for 'foreshadowing' monsoon rainfall, which has continued in use in India with but little amendment. Walker would not claim to have solved the monsoon problem, but he pointed a way, and the value of these papers can scarcely be overestimated.

Living in the Simla hills, Walker was fascinated by the soaring flight of birds, at first as a hobby, then as a study on which he wrote several papers, including the article in the "Encyclopædia Britannica" on animal flight.

After retiring from India in 1924, Walker succeeded Sir Napier Shaw as professor of meteorology at the Imperial College of Science and Technology, London. One of the subjects to which he turned his own and his pupils' attention was the cellular structure of an unstable fluid. In striking laboratory experiments they obtained a variety of cellular forms—polygons, transverse and longitudinal vortices—by varying the rate of shear in the fluid, and they were able to show that this physical process explained the mode of formation of a wide variety of cloud forms.

Walker lived in Cambridge from 1934 until after the Second World War, officially retired but continuing to write papers on meteorological subjects. During the War he acted, in effect, as an honorary consultant on problems of long-range forecasting.

Walker was a man of wide interests, a highly proficient skater and climber in his younger days, always very fond of music, happy to spend a day out of doors sketching in water colour, ever eminently reasonable, liberal minded and very friendly. In all his posts he demonstrated his great intellectual capacity and served with distinction, deservedly reaping many honours during his long life.

CHARLES NORMAND

Mr. Stephen Butterworth, O.B.E.

STEPHEN BUTTERWORTH died on October 28 at the age of seventy-three at his home in Cowes, Isle of Wight, having retired from the Admiralty scientific staff in 1945.

After being educated at the University of Manchester, Butterworth was for eleven years a lecturer in physics at the Manchester Municipal College of Technology. Afterwards he worked for a few years on electrical standards at the National Physical Laboratory before joining the Admiralty Research Laboratory in 1921, where he remained for twenty-four years until his retirement.

Butterworth was a first-rate mathematician who possessed the rare ability to apply his mathematics successfully to a wide variety of practical problems. Before his Admiralty period he was mainly concerned with electrical investigations such as the theoretical determination of standards of inductance and accurate methods of measurement. This work, unlike much of what he did later, was fully published in the scientific Press, and his theoretical formulæ for inductances and the high-frequency resistance of coils have been extensively quoted and used.

His achievements with the Admiralty are too numerous to mention in detail, but the following indicate the diversity of his activities. In his early days he studied the possibilities of ship navigation by the use of a 'leader cable'; and, by solving the complicated electromagnetic field surrounding a submarine cable carrying alternating current, he was able to provide a complete theoretical background for all subsequent design work. He concerned himself with underwater weapons and made valuable contributions to our understanding of the stability of torpedoes which led to significant improvements in design. At another period he gave his attention to underwater explosion phenomena and among other things predicted the multiple oscillations of the explosion gas bubble, an effect that was observed experimentally many years later. In the early part of the Second World War he was much involved with the problem of the magnetic mine and made big contributions to the successful degaussing of our ships.

Butterworth possessed the ability to apply his mathematics to problems which at first sight appeared unlikely to admit of mathematical solution. He was, however, able to make progress in many cases by introducing judicious approximations to the physical conditions. Naturally, much depends on knowing the right approximations to make, and in this respect Butterworth invariably displayed an unerring understanding of the physical realities of the situation. He also showed ingenuity in devising experiments both to test his theories and to make progress with problems too complex for mathematical treatment. Naval science is often concerned with large-scale effects, where systematic and extensive experimentation is very difficult. In such cases he would aim at devising a model which could be studied exhaustively in the laboratory. He was able to show, for example, that the complicated details of magnetization of a ship's structure under the combined influence of its degaussing coils and the magnetic field of the Earth could be accurately reproduced using an appropriately scaled steel model of the ship. This made possible an enormous saving of effort when degaussing specifications had to be worked out for a variety of ships during the Second World War. In the same way, he was able to study the trajectories and the effects on entering the water of underwater projectiles by means of small models in a laboratory tank, thus reducing the need for difficult and expensive full-scale experiments at sea. In this case the technique which he developed at Teddington many years ago has been followed by other laboratories ever since.

For security reasons it was impossible for Butterworth to publish much of his work, and on this account his general recognition in the scientific world has been much less than it would otherwise have been.

Although one of the most outstanding scientists in the Admiralty's service, Butterworth was a very quiet and unassuming man. His expert advice was sought on all sides, and he was always ready to give it. His colleagues throughout the Admiralty scientific service had deep respect for him, and those young men fortunate enough to work under his direction held him almost in veneration. H. F. Willis

NEWS and VIEWS

The Queen's University, Belfast: Prof. Michael Grant, C.B.E.

Prof. Michael Grant, who holds the chair of humanity in the University of Edinburgh, has been elected president and vice-chancellor of The Queen's University, Belfast. He will succeed Sir Eric Ashby (who takes up residence as master of Clare College, Cambridge, next July) in August 1959. Prof. Grant brings a wealth of experience to his new office. He was educated at Harrow and Trinity College, Cambridge. In 1938 he was elected into a Fellowship at Trinity. During the War he was seconded from the Army as British Council representative in Turkey and he later became deputy director of the European Division of the British Council. In 1948 he was appointed professor of humanity in the University of Edinburgh, and during 1956–58 he had leave of absence from his chair to serve as first vice-chancellor of the University of Khartoum. He filled the office of vice-chancellor at Khartoum with distinction through a period of great political and constitutional unrest. Prof. Grant goes to The Queen's University at a time when it is developing rapidly. He will have the double responsibility of maintaining the University's international status and at the same time preserving the University's close ties with its region. He has high qualifications for this double responsibility, and it is a cause of great satisfaction that university education in Ulster will be under such experienced leadership.

Department of Leather Industries, University of Leeds: Prof. D. Burton

It has been announced that Prof. D. Burton is to retire in September 1959 from the chair of leather industries in the University of Leeds, which he has held since 1951. Since 1955 he has also been director of the Procter International Research Laboratory, where he was at one time the first research assistant. During his tenure of office there has been a considerable expansion of the activities of his Department. The courses have been revised and the research facilities greatly extended; an electron microscope has been installed and put to good use; the experimental tannery has been modernized and re-equipped; a laboratory for microscopy and bacteriology has been opened; and the Atkin–Thompson postgraduate research laboratory added. Among the topics studied has been the nature and material of the Dead Sea Scrolls. Prof. Burton is widely known and respected in the leather industry as well as in academic circles, and a large number of friends will wish him well in his retirement.

Prof. A. G. Ward

Mr. A. G. Ward has been appointed to succeed Prof. Burton. After obtaining first-class honours in physics at Cambridge and working, for a time, in the Department of Colloid Science in that University, Mr. Ward was lecturer in physics and mathematics at the Technical College at Stoke-on-Trent, until the Second World War, when he worked with the Armament Research Department. During 1946–49 he was in charge of research on rheology at the Building Research Station, after which he became the first director of the British Gelatine and Glue Research Association. Apart from his duties as director, Mr. Ward has made notable advances in our knowledge of the properties of gelatine. His authoritative article (with P. R. Saunders) in the recently published second volume of F. R. Eirich's "Rheology: Theory and Applications" is of outstanding merit. Though Mr. Ward's interests cover a wide field of colloid science, and his little book on colloids, published in 1945, has been much praised, he is perhaps best known as a rheologist. He was president of the British Society of Rheology during 1951–53, his term of office including the Second International Congress on Rheology held at Oxford. As president, he also served as chairman of the organizing committee of this Congress, in which capacity his administrative abilities and keen business acumen were greatly appreciated.

Molecular Biology in the University of Oregon : Dr. A. Novick

DR. AARON NOVICK, who has been on the staff of the University of Chicago for eleven years, has recently been appointed director of the Institute of Molecular Biology at the University of Oregon. He graduated in chemistry in 1940 and received the degree of Ph.D. in 1943, both in the University of Chicago. Dr. Novick's research has been principally in the genetics and physiology of micro-organisms, reaction kinetics, nuclear measurements and radiation chemistry. During 1943–47 Dr. Novick was with the Manhattan District Project, when he worked in the fields of radiation chemistry, radiochemistry and nuclear physics. In 1947 he was made a research associate with the rank of assistant professor in the Institute of Radiobiology and Biophysics of the University of Chicago. He worked as a Guggenheim Fellow at the Pasteur Institute in Paris during the year 1953–54 before returning to Chicago as associate professor.

European Organization for Nuclear Research

THE Council of the European Organization for Nuclear Research (CERN) recently approved contributions from the twelve member States totalling 55,000,000 Swiss francs for 1959 (compared with a budget of 56,000,000 Swiss francs for 1958). Good progress was made during 1958 in the construction of the Organization's two big particle accelerators and of other buildings and ancillary facilities. The first machine, a 600-MeV. synchrocyclotron, came into operation on August 1, 1957. It was recently used to demonstrate, for the first time, the two modes of decay of π-mesons—an experiment of critical importance to fundamental nuclear theory. In view of the rapid progress made at the CERN building-site during 1958, the second accelerator, the 25-GeV. proton-synchrotron, will probably be finished in 1960, the target date originally set. It will then be the biggest particle-accelerator in existence.

Prof. P. Scherrer (Switzerland) and Dr. G. Funke (Sweden) were elected as new members of the Committee of Council. Sir Harry Melville, secretary of the Department of Scientific and Industrial Research of the United Kingdom, was re-elected as member of the Committee. The following were also re-elected : M. F. de Rose (France) as president of the Council ; Prof. W. Heisenberg (German Federal Republic) and M. J. Willems (Belgium) as vice-presidents of the Council ; M. J. H. Bannier (Netherlands) as chairman of the Finance Committee ; Prof. E. Amaldi (Italy) as chairman of the Scientific Policy Committee ; and Prof. W. Heisenberg (German Federal Republic) and Prof. H. Alfvén (Sweden) as members of the Scientific Policy Committee.

Calder Hall Completed

ALL the reactors at the two Calder Hall nuclear power stations are now working. This stage was reached during the night of December 8–9 when the fourth reactor on the site went critical. The operation was successful and this reactor will now undergo a series of tests while working up to full power in preparation for linking with the grid system to provide electricity. There are two atomic stations at Calder Hall, known as 'A' and 'B'. Work on the first of these started in the summer of 1953 and on the second in 1955. Each station has two reactors and the first of the two in Calder 'A' started operating in May 1956. It achieved full power and was switched into the grid on October 17, 1956, by Her Majesty the Queen. It thus became the first atomic power station in the world to produce electricity on a commercial scale. Both the reactors on the first station have been successfully supplying electricity to the national grid system since February 1957. The power capacity of the four turbo-generators associated with the two reactors is 92 megawatts, of which about 70 megawatts is used by the grid. So far just over 750 million kilowatt hours have been supplied. The first reactor of Calder Hall 'B' started operating in March this year and has been running successfully. Delivery of power was delayed by an accident to a turbo-generator in June, but will probably take place before the end of the year. The last reactor to start operating will start production of electricity two or three months later. The two stations together will have a capacity of 184 megawatts and will supply 140 megawatts to the national grid. A similar station with four reactors is now nearing completion at Chapelcross, near Annan in Dumfriesshire. One of the reactors here is already operating and the whole station will be complete by the end of next year.

Import Duty on Scientific Apparatus and Instruments

IN a written Parliamentary reply on December 10, Sir David Eccles, president of the Board of Trade, stated that arrangements are being made for widening the scope of the arrangements for remitting duty on optical and scientific apparatus and instruments. The Board will be prepared to consider such apparatus and instruments imported on and after January 1, which satisfy the definition in the Import Duties Act, 1958, where the rate of duty is 25 per cent or more (minimum chargeable, £50). The President set out a list of apparatus and instruments which will be so considered, provided that they are not obtainable, for the time being, in the United Kingdom.

Josiah Wedgwood and Research

COMMENTING on the paragraph under this heading in *Nature* of October 25, p. 1130, Dr. A. T. Green, director of research of the British Ceramic Research Association, writes : "This is a striking example of his remarkable foresight, but I should like to point out that the letters between Wedgwood and Bentley, describing the former's efforts to persuade his fellow potters to co-operate in this venture, were rather fully extracted some 28 years ago in the "Wedgwood Bicentenary Volume" of the British Ceramic Society. The fact that Wedgwood, in 1775, proposed the formation of what might have been the first research association, has frequently been mentioned and is a matter of some pride to those of us engaged in ceramic research at the present time".

Northern Advisory Council for Further Education

THE eleventh annual report of the Northern Advisory Council for Further Education, which covers the year ended March 31, 1958, records the decision of the Minister of Education to develop the Rutherford College of Technology into a college of advanced technology (see *Nature*, **179**, 1277; 1957), and the Committee of Chief Education Officers has already submitted recommendations on advanced courses. Among the new buildings noted in this report are the second instalment of Carlisle Technical College, to be ready for occupation for the session 1959–60; completion of the first phase of additions to the Workington College of Further Education: full completion of the Joint Stockton/Billingham Technical College; completion of the first instalment of the Durham Technical College and the Bishop Auckland Technical College; commencement of the third stage of the new Rutherford College of Technology; and the coming into use of the first instalment of Easington Technical College; the first instalments of the County Technical College, Ashington, and the South Shields Marine and Technical College; and of major extensions to the Sunderland College of Art. After a general review of the Willis Jackson report on the "Supply and Training of Teachers for Technical Colleges", the programme committee recommended that the Advisory Council should take appropriate steps to implement the recommendation that industry should be more fully acquainted with the staffing problems of colleges; that through the programme committee it should prepare a comprehensive programme of part-time courses of training for technical teachers, and that a proper service of organizing tutors should be established. The first series of short initial training courses for new teachers in technical colleges was held at Middlesbrough, Newcastle and Workington.

The International Institute for the Conservation of Museum Objects

The International Institute for the Conservation of Museum Objects was founded to provide a permanent organization to co-ordinate and improve the knowledge, methods and working standards needed to protect and preserve precious material of all kinds. Dissemination of information on research into and development of all processes connected with conservation, both scientific and technical, is an essential part of its function. A substantial grant from the Gulbenkian Foundation, covering the next three years, has recently been received by the Institute. Since 1950 the Institute has expanded continuously, until now it has members in more than thirty countries and in most major museums of the world. It has published its journal, *Studies in Conservation*, which carries out the Institute's policy of disseminating information, since October 1952 (hitherto published twice yearly, but quarterly beginning 1959), and *Abstracts of the Technical Literature on Archaeology and the Fine Arts* since 1955. Members are kept in touch with each other by means of the *News Letter*, which also carries items of special interest, and which has been published by the American Office of the Institute since 1952. One of the most important functions of the Institute is to be able to put members in touch with the appropriate experts in any particular field of conservation. This is a service which is constantly expanding, and although up to the present time it has been available to members only, it is hoped to be able to extend the service to the general public in 1959. The Institute, while not possessing a laboratory of its own, is in touch with all institutions which specialize in technical research and development relating to the care of artistic patrimony, and has become one of the internationally recognized channels for the communication of their results.

In order to increase the international character of the Institute, the former Management Committee retired in January 1958, and was replaced by a ten-member Council, representing approximately the present topographical distribution of members of the Institute. Its members are: *President*, W. G. Constable; *Vice-Presidents*, Dr. P. B. Coremans, Dr. H. J. Plenderleith, F. I. G. Rawlins; *Secretary-General*, N. S. Brommelle; *Treasurer*, S. Rees Jones; *Ordinary Members of Council*, R. J. Gettens, Dr. S. Paramasivan, Dr. A. van Schendel, G. L. Stout; *Membership Committee*, Dr. Paul Coremans, Sheldon Keck, Dr. Arthur van Schendel, Mme. Magdeleine Hours, the Secretary-General (*ex-officio*). Information concerning the Institute can be obtained from the assistant secretary, Miss R. M. Spielman, c/o The National Gallery, Trafalgar Square, London, W.C.2.

Electric Technology, U.S.S.R.

The increasing importance of Russian scientific and technical literature is reflected in the appearance of journals comprising selected papers and articles translated from the Russian. A recent addition to this series is *Electric Technology, U.S.S.R.* (four volumes comprising approximately 700 pages per annum. Annual subscription £20 (56 dollars); single volumes £6 (17 dollars). London and New York: Pergamon Press, 1958), containing translations of articles from *Elektrichestvo*, the leading Russian journal dealing with heavy-current electrical engineering and, incidentally, one of the oldest electrical journals in the world. It is proposed to publish in the new journal only those articles from *Elektrichestvo* having the greatest general interest and value. The publishers state, however, that they will be able to provide a translation of any article which has appeared in the Russian journal. The contents of the first issue represent papers selected from *Elektrichestvo*, Nos. 1–4, 1957, and cover a wide range of topics, including, for example, short-circuit transients on long lines, the problem of impulse tests on the turn insulation of a high-voltage machine, the use of amplidyne and transistor amplifiers in industrial drives, the measurement of earth resistances and the stabilities of measuring instruments using 'Magnico' and 'Alnico'.

While it is no doubt true that the existing abstracting, translating and reprint services cover the field of Russian scientific literature very satisfactorily and provide the scientist and engineer with copies of specific papers which he may wish to consult, there does appear to be a useful purpose to be served by a journal which selects, translates and publishes at intervals the most important Russian articles in a given field. Such a publication enables the reader not only to form some picture of the range of work being done in his field but also to read, from time to time, an important paper in full, without requiring to take special steps to obtain it in translation. *Electric Technology, U.S.S.R.*, is a welcome addition to the literature of electrical engineering.

International Glossary of Wood Anatomy

It is very satisfactory to find that action is being taken in several scientific fields to secure agreement on the precise meaning of the many special terms that have come into use among research workers and others. Relatively few such terms have been deliberately invented and defined on introduction into the literature, and even of these a large proportion tend, with time, to be loosely used, sometimes with a meaning very different from what was originally intended. In this way, ambiguity creeps in, causing confusion until action is taken to secure standardization, or at least definition, and indication of preferred usage. Among the groups to take action of this kind is the International Association of Wood Anatomists which, realizing the need for revision of the glossary produced in 1933, has recently published a new glossary of more than two hundred terms with definitions (*Tropical Woods*, No. 107; October 1957: International Glossary of Terms used in Wood Anatomy. Pp. 36. Zurich: International Association of Wood Anatomists, Universitätstrasse 2; New Haven, Conn.: Prof. William L. Stern, 205 Prospect Street, 1957). By a fortunate coincidence, the second part of a British Commonwealth Forest Terminology was under compilation at the same time and agreement has been secured for all the terms included in both. Furthermore, it has been agreed that these English glossaries, co-ordinated so far as possible with the American equivalents, are to form the basis of multi-lingual glossaries for international usage. This is an important step in the right direction.

Gairdner Foundation Awards in Arthritis and Heart Disease

THE Gairdner Foundation has announced its first international awards in arthritis and heart disease, totalling 40,000 dollars. Medical scientists from Britain, the United States and Canada are included among the seven recipients. The Gairdner Foundation Award of Merit of 25,000 dollars has been awarded jointly to Dr. Alfred Blalock and Dr. Helen B. Taussig (Johns Hopkins University, Baltimore) for their initial development of what is popularly known as the 'blue-baby operation' for congenital obstruction of the pulmonary artery. Three annual awards of 5,000 dollars each have been awarded to the following: Profs. H. M. Rose and C. Ragan (Columbia University, New York) for their discovery of an agglutinating reaction affording the first practical laboratory blood-test for the diagnosis of rheumatoid arthritis; to Prof. W. D. M. Paton (Royal College of Surgeons of England) and Prof. Eleanor Zaimis (Royal Free Hospital School of Medicine, London) for their discovery of the methonium compounds, the first drugs effective in the treatment of high blood pressure; to Dr. W. G. Bigelow (University of Toronto) for his development of the technique of hypothermia for heart surgery.

Christmas Lectures at the Science Museum

CHRISTMAS lectures for children aged thirteen to seventeen years are to be given for the first time this year at the Science Museum. There will be two subjects: first, "From Man Power to Atomic Power" on December 31, repeated on January 1 and 2; second, "The Story of Flight" on January 5, repeated on January 6 and 7. The lectures will be illustrated by many demonstrations and the young audiences will be able to see such things as a Montgolfier hot-air balloon rising to the ceiling of the lecture theatre and a noisy and spectacular 'mock-up' of a gas turbine. The lectures will commence at 2.30 p.m. and admission is free and without ticket.

Science Museum Exhibition on Controlled Nuclear Fusion

A SMALL exhibition at the Science Museum, South Kensington, open from December 18 until the end of March 1959, illustrates British research in the field of controlled nuclear fusion. The centre-piece of the exhibition is a one-third scale model of Zeta, the apparatus developed at Harwell. This model was shown in the exhibition held at Geneva last September in connexion with the Second International Conference on the Peaceful Uses of Atomic Energy, and simulates the flashing discharge which in Zeta produces fusion of atoms. Another scale model, which was on view for six months at the Brussels World Fair, shows the apparatus known as Sceptre III, which was made by Associated Electrical Industries, Ltd., and gives results similar to those obtained with Zeta. Examples are also shown of pioneer apparatus used at the beginning of this type of work twelve years ago.

Announcements

THE Agricultural University of Wageningen is organizing an international conference on "Enzymes and their Action", to be held at Wageningen during April 6–10. Further information can be obtained from Dr. H. Veldkamp, Laboratorium voor Microbiologie, Hesselink van Suchtelenweg 4, Wageningen, The Netherlands.

AN international conference on "Co-ordination Chemistry", under the sponsorship of the International Union of Pure and Applied Chemistry, will be held in London during April 6–11. The conference is being organized by the Chemical Society, and further information can be obtained from the Secretary, International Conference on Co-ordination Chemistry, Chemical Society, Burlington House, London, W.1.

A SYMPOSIUM on "The Biology of Weeds" is being arranged by the British Ecological Society, to be held in Oxford during April 2–4. The programme will include papers on the ecology, systematics and physiology of weeds, the origin and development of weed floras, competition and population studies in weeds, and dormancy characteristics of weed species. Limited accommodation will be provided in Brasenose College. Inquiries should be addressed to Dr. J. L. Harper, Department of Agriculture, University of Oxford.

THE Institute of Physics is arranging a conference on "Some Aspects of Magnetism", to be held in Sheffield during September 22–24, 1959. The subjects to be covered by the conference are: (*a*) fundamental theories of ferro-, ferri- and antiferro-magnetism, including magnetic structure; (*b*) theories of technical magnetization processes, including hysteresis, coercivity, anisotropy and directional effects; (*c*) domain phenomena in bulk materials and thin films; (*d*) antiferromagnetism in metals and non-metals. Each session will be opened by an invited speaker, and other contributions should be submitted to the Conference Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1, before January 31. Abstracts (but not preprints) will be circulated before the conference, the proceedings of which will not be published in full.

REORGANIZATION OF THE METEOROLOGICAL OFFICE

IN 1955 a small committee with Lord Brabazon as chairman was appointed by the Secretary of State for Air to review the organization of the Meteorological Office. The quite radical changes that followed the investigations and recommendations of the Brabazon Committee took effect on July 1, 1957, and their nature is described in the annual report of the Meteorological Office*.

It was as a department of the Board of Trade, serving the interests of shipping, that the Meteorological Service began its existence in 1855, and it assumed the name by which it is now known when it was later transferred to the control of a committee nominated by the Royal Society. The Office retained its autonomy as a separate Government department through several succeeding reorganizations, until, in 1919, the War Cabinet decreed that it should absorb the three separate meteorological units which had been established to serve the needs of the Royal Navy, the Army and the Royal Air Force, and that it should henceforth become attached to the department making the greatest use of its services, the Air Ministry. A Meteorological Committee composed of representatives of its principal customers, of the Royal Societies of London and Edinburgh, and of the universities, was set up to act as a board of management.

During the period between the two World Wars, the comparatively small scientific staff was, in the main, fully occupied in operational forecasting, which inevitably involved liability for work at irregular hours and frequent transfers between stations at home and abroad, many in isolated situations. Less-favourable conditions for research can scarcely be imagined, yet some members of the staff successfully undertook investigations of fundamental importance, mostly in their leisure hours.

During the Second World War, the director, the late Sir Nelson Johnson, instigated two important developments with the aim of furthering the progress of research within the Office. The Meteorological Research Committee, composed of senior scientists from within the service and from the universities, was established in 1941 with the object of providing advice on the general planning of the programme of research. During the next year the Meteorological Research Flight was set up at Farnborough and has now behind it a substantial achievement that has earned an international reputation.

It was probably the difficulty experienced after the War in securing adequate staff with the necessary qualifications that was the principal reason for the appointment of the Brabazon Committee, a year after Sir Graham Sutton had assumed the post of director. (The full report of the Brabazon Committee has not been published.) The difficulty of recruitment was partly due to the irregular hours of duty that must be served by the practising meteorologist and partly to the remote situation of many stations. Besides, there are few appointments for the trained meteorologist outside the Office, and it was common knowledge that opportunities for promotion to senior posts compared unfavourably with those in most other branches of the Scientific Civil Service. The reorganization that has now taken place will do much to remedy this state of affairs. New posts have been created in the highest grades of both the scientific and experimental officer classes and the total number of posts in the scientific officer class (145 at present) has been slightly reduced to ensure that all entrants in this class will have an expectation of reaching at least the rank of senior principal scientific officer within a reasonable period.

The further recommendations of the Brabazon Committee that have been promulgated in the annual report reveal that the scope of the Committee's survey has been wide. The continued progress and the high standing as a scientific institution acquired while the Office has been under the Air Ministry are taken to indicate that the Meteorological Office is in its right place in the Government organization. The post of director is raised to that of director-general, and there are now two directors in the grade of chief scientific officer, Dr. J. M. Stagg and Dr. R. C. Sutcliffe, responsible for services and research, respectively. In addition, there is a third section for administrative and general duties, headed by an assistant secretary, to be known as secretary to the Meteorological Office, a change which will presumably relieve the senior scientists of considerable administrative duties and at the same time make the Office a more self-contained unit.

The Meteorological Committee, established in 1919, is deemed to be too large and has been replaced by an Advisory Committee of "not more than five members, all outside Government service". Its functions are "to keep under review the progress and efficiency of the Meteorological Office and the broad lines of its current and future policy as well as the general scale of effort and expenditure". Its first chairman is Lord Hurcomb, and the members are Sir Austin Anderson, Sir David Brunt, Sir Charles Normand (*ex-officio* as chairman of the Meteorological Research Committee, which is to continue unaltered) and Col. Stopford Sackville.

The plans for improved facilities for research are imposing. Already, during the past decade, a steadily increasing series of papers, impressive both in quality and quantity, has come before the Meteorological Research Committee. This has been made possible by assigning many forecasting duties to experimental officers, so permitting the allocation of research tasks to the scientific officers, freed from operational work at out-stations. The tendency for delay in the practical application of the results of research is recognized by the appointment of a new assistant director, who will not only keep the forecasters acquainted with the progress of research that may be valuable to them but will also formulate, for presentation to the researchers, new problems that arise from the experience of the forecasters.

There appears, however, to have been no examination of the somewhat anomalous position of the three British magnetic observatories. Two of these, at Lerwick and Eskdalemuir, are administered and staffed by the Meteorological Office, the third at Hartland Point (previously at Abinger) by the Royal Greenwich Observatory. The staff who have been posted to the Meteorological Office observatories have had to divide their allegiance between the almost unrelated sciences of meteorology and geomagnetism, for no senior post has been attached to the latter. Nevertheless, this association of geomagnetism with the Meteorological Office has been not unsuccessful, for the traditions established by Chree have been well maintained by Goldie, Stagg, and more recently, McIntosh and Lewis. Yet there is surely a strong case for the establishment of at least one senior observatory post so that a man of proved ability in geomagnetic studies, who wishes to devote himself to such work, may do so without sacrificing his prospects of promotion.

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* Annual Report on the Meteorological Office for the year April 1, 1957, to March 31, 1958. Pp. 52+4 plates. (M.O. 650.) (London: H.M. Stationery Office, 1958.) 3s. 6d. net.

The annual report begins with a summary by the Director-General of the changes as they affect the Meteorological Office as a public service and scientific institution. In this, Sir Graham Sutton points out that the advantages of the reorganization will be fully realized only when the staff at present at Victory House, Harrow, Dunstable and the Training School at Stanmore move together to occupy the new buildings, now being erected at Bracknell and likely to be completed in 1961. There follows a detailed account by the Director of Services of the responsibilities of his directorate, which includes not only general forecasting for a wide range of customers, but also the complex organization of communications, the observations, both surface and upper air, on land and at sea, the climatological services, agricultural meteorology and training. The Director of Research summarizes the various problems now under investigation and discusses the work of instrument development, which is also his responsibility. Research on numerical forecasting, involving the development of techniques for predicting the pressure distribution by calculations from the dynamical and physical equations by means of an electronic computer, is being actively pursued. This very readable report concludes with two short chapters on international co-operation and administration.

With the recent rapid development of techniques for the measurement of the physical structure of the atmosphere to great altitudes and their wide use throughout the world during the International Geophysical Year, the mass of new data which is becoming available will make possible the investigation of many fundamental problems in meteorology that were hitherto intractable. The quite excellent facilities for this research which are now provided in the Meteorological Office have therefore been achieved at an opportune time, and it can be confidently anticipated that the national service will play an increasingly important part in advancing the science of meteorology.

J. PATON

SUPPLY AND DISTRIBUTION OF CHEMICAL ENGINEERS IN BRITAIN

THE Institution of Chemical Engineers, ever since its inception thirty-five years ago, has pressed for an appreciation of the importance of chemical engineering in the national economy and has made unceasing efforts to promote the training of chemical engineers; but development in Britain lagged far behind that in the United States, and it was not until the beginning of the Second World War, when the University of London was persuaded to institute a degree in chemical engineering, that the profession was generally recognized as a separate discipline. From that time progress was more rapid, and in recent years, following the national awakening to the importance of professional engineers and the multiplication of training courses, the number of chemical engineers has increased still more rapidly. The increase would have been greater still but for one factor, long foreseen by the profession—the ever-growing difficulty of obtaining qualified teachers. A state had been reached in which a promising graduate, immediately on leaving the university, could secure a higher salary in industry than some of those who had taught him. It was consequently not surprising that there were few candidates for teaching posts.

Earlier this year the Institution published a survey of output of chemical engineers in Great Britain, from which it was concluded that by 1966, provided the situation as regards teaching staff did not become worse, the yearly output might be about 950, as against a requirement of at least 1,100 (see *Nature*, 181, 1382; 1958). This would be an improvement on the present position but would still leave a shortage. Statistical information on this subject is scanty and the Institution has recently circularized its qualified members in order to ascertain where they work, in what industry and what position they hold. Salaries, unfortunately, have been omitted. 79 per cent made returns and it was hoped that these might indicate a special shortage of chemical engineers either in certain regions, industries or occupations. The results are interesting, but difficult to interpret; for example, the number of chemical engineers in a given region depends mainly upon the number of factories of a type employing a high proportion of chemical engineers (for example, oil refineries) which happen to be located in that region. It also depends on the prospects which the new recruit considers that these factories offer and on the amenities of the district. A low figure for any region does not necessarily indicate that many more chemical engineers are required there.

The returns showing the occupation of members are more illuminating, as they can be compared with similar figures for 1953. In that year, about 20 per cent were engaged in each of four main branches: (1) administration and management; (2) plant operation and maintenance; (3) design and construction; and (4) research and development. In 1957, no less than 30 per cent were occupied in administration; a remarkable increase, due, perhaps, to the multiplicity of subjects, not all purely technical, which chemical engineers have to study and the wide outlook which results. This increase is offset by a reduction from 22·8 to 12·3 per cent in the numbers engaged in the operation and maintenance of chemical plant, and is a welcome sign since it not only indicates the advancement of automatic control but also a diminution of the employment of graduates in duties which could be carried out equally well by those with lower qualifications. It is surprising to find that corresponding figures for two of these major branches in the United States differ considerably, being 31 per cent for research and development compared with 23 per cent in Britain, but only 7 per cent for design and construction against 21 per cent, a possible explanation being that development may be carried further in the United States and may include much which is classed as design in Britain. Among the minor occupations, teaching shows a gratifying increase from 3·0 to 5·1 per cent, the present number of teachers being more than 100, but this is still not enough.

The total number of qualified members of the Institution in 1957 was 2,176, a figure considerably higher than that given in the Government report on Scientific and Engineering Manpower in 1956. The distribution of these members among thirty-three different industries and occupations is shown and also the number of chemical engineers per 1,000 males employed. As might be expected, the mineral-oil refining industry, which may be regarded as the cradle of chemical engineering, heads the list with 7·3 chemical engineers per 1,000 employed, and it may also be noted that it was calculated some years ago that the value of the product per man-hour in the oil industry was far higher than in any other heavy manufacturing industry. Oil refining seems to be approaching a state in which the only labour required will be for the erection and maintenance of plant, operation being entirely automatic, and its chemical engineers are employed in research, design, development and management. It would, however, be unwise to conclude from this that the efficiency of an industry is directly related to the number of chemical engineers employed. The iron and steel manufacturing industry, in which many chemical engineering processes are involved, employs only twenty chemical engineers, or 0·05 per 1,000 males, and is at the bottom of the list. It is true that automatic operation has not been adopted in this industry to the same extent as in the case of oil, but this is doubtless because it would be more complicated and difficult to install, and would probably be uneconomic. There is certainly no question of the iron and steel industry being inefficient, but there is a possibility that it does not recognize fully the potentialities of the chemical engineer, and that many of the highly qualified staff who are, in effect, doing chemical engineering work were recruited as metallurgists or mechanical engineers. This example may show the difficulty of interpreting employment statistics.

Of the other items in the list of industries, one is deserving of particular attention, namely, atomic energy. This has already secured the services of more than one hundred chemical engineers, and it seems certain that the number required in the near future will be very large.

All the figures now published will have their real value in the future. It is to be hoped that a similar set will be published in about five years time, and it may then be possible to make reliable predictions. Even now, it may be regarded as a practical certainty that there will be no over-production of chemical engineers in the coming quinquennium.

H. E. WATSON

FUEL AND POWER IN BRITISH INDUSTRY

It is abundantly clear that the supply of suitable fuels and the provision of adequate power represent essential factors in any efficient industrial unit. It may well be doubted, however, whether, in view of the ever-increasing complexity of the situation, those responsible for important industrial decisions are always in a position to appreciate thoroughly all the technological and commercial factors involved. It was in the hope of doing something to assist in the planning of such development, so far as the supply of fuel and power is concerned, that the Manchester Joint Research Council arranged a symposium during November 5–7, which was held at the Manchester College of Science and Technology. A very large amount of material has been published on these matters from the technological point of view, and it was not the intention of the Council in organizing the symposium to duplicate this, the general theme of the meeting being the interaction between technological advances and their economic consequences.

The meeting was opened by Lord Mills, Minister of Power, who summed up the Government's policy as permitting the consumer to decide from his own experience what is required to meet his own particular needs, coupled with the provision of expert advice, where this is required. It has been estimated that by 1965 the total fuel consumption of the United Kingdom will have risen to about 300 million tons of 'coal-equivalent' a year and to 350 million tons by 1975. A marked change in the pattern of the fuel and power used is to be expected; there will probably be a continued switch from the direct use of raw coal to its application in the more refined forms of gas and electricity and an increase in the use of oil, due to the continued expansion of road transport, the re-equipment of the railways, the continuance of recent trends in domestic heating and the change from solid fuel to oil in those industrial and commercial uses where it has special attractions.

This greater refinement means heavy capital investments but offers great savings both in operating and fuel costs, and, in addition, there is a marked reduction in the atmospheric pollution associated with the use of solid fuel.

It is often argued, the Minister said, that the Government should direct the fuel to be used for specific purposes. In reply to this he added: "We should certainly hesitate to adopt such a policy of Government direction on fuel use for two main reasons. In the first place, the detailed policy of control could not really work; there is so much uncertainty regarding the best fuel to employ in particular conditions and, secondly, if there is one thing which central control lacks it is flexibility. A pattern laid down as appropriate at a particular time might quickly become obsolete and uneconomic". It is important, too, in his view, that the importation of oil should be in the crude form, from an increasing variety of sources and processed at refineries in the United Kingdom.

So far as nuclear power is concerned, there would be a rapid expansion to some 5,000–6,000 megawatts in 1966, and thereafter continued expansion may prove economic. Concerning the use of small coal, this should become progressively a more attractive purchase, and it is the duty of all forms of industry, nationalized or otherwise, to switch their demands so far as possible from larger sizes to small coal.

The remainder of the meeting was devoted to the industrial consideration of oil, coal, gas, electricity and nuclear energy. The lectures on oil were given by Dr. P. H. Frankel, of Petroleum Economics Ltd., who dealt with the economic aspect, and Mr. W. S. Ault and Mr. H. Cunliffe, both of Shell-Mex and B.P. Ltd., who were concerned with the uses. Dr. Frankel, in a most valuable and provocative paper, suggested that with the expansion of existing oil-fields and the opening of new ones—the Sahara was mentioned in particular—there would appear to be abundant reserves on a world scale. Great Britain, however, is especially subject to political vicissitudes, and he therefore stressed the need for a balanced fuel economy. In the past few years vast new oil fields have been found, the exploitation of which, now that they have been located, should be relatively cheap. This oil will tend to press on the existing markets, and he assumed, therefore, that the price of liquid fuel would tend to fall. A question which he posed to the Conference was whether it is more economic for Great Britain to go to the limit of marginal high-cost production of coal with investment on a commensurate scale, or to substitute oil for, say, the last 10 per cent of our requirements. He pointed out that Western Europe is dependent on sea-borne oil, but he believes that there are plenty of tankers available, while pipe-lines based on Marseilles, Rotterdam and Hamburg would facilitate distribution.

Mr. Ault and Mr. Cunliffe's paper on the uses of oil, after stressing its importance in all forms of transport, passed on to consider its use in general industry. Although electrical energy can be produced from coal at the generating station at the lowest cost, there are even here special cases in which oil-firing is worthy of consideration. The efficiency of combined generation of electricity and recovery of waste heat, using either Diesel or gas turbine or both, was given as 80 per cent. The storage space required for oil fuel is much lower than that needed for coal, and oil firing offers further advantages in mechanical equipment, labour costs, convenience and automatic control. Furnaces may be heated by a wide variety of fuels, ranging from propane to heavy fuel oils, and in such processes as steel-making the high radiation from the flame leads to more rapid melting. The question of atmospheric contamination by sulphur was mentioned, though in subsequent discussion it was not clear that, from this point of view, oil is markedly superior to coal. It does, however, possess marked advantages in the absence of grit turned into the air.

In his review of Britain's resources of coal, and considering seams not less than 1 ft. thick and not more than 4,000 ft. deep, Mr. A. M. Wandless (National Coal Board) estimated that these are of the order of 1,000 million tons which can be economically worked. He stressed the fact that it is not the mere quantity available but the 'rank', of which the coals proved cover a range unique in Western Europe. With the increase of mechanization the increased costs of production are not likely to go on rising unchecked. This cost of production varies inversely with the rank, of which the various industrial uses extend over a wide range, and low rank does not necessarily imply low quality. The present output of the various types of coal is not seriously out of phase with the resources of Britain, though a slow decline in quality must be expected. About half the output is of low rank, and it is for the technician to ensure that the use of such coal should be as great as possible.

One of the most important contributions was that of Mr. D. Hicks (National Coal Board), on "Coal Utilization". Although the total mineral resources of Britain are limited in type, they are not insignificant in quantity. There is, for example, enough economically accessible coal to sustain a high national productivity for more than a hundred years. It would seem wise to ensure that these natural advantages are not used carelessly, and that we do not become increasingly dependent on external resources, with all the uncertainties and risks, political and economical, that this implies.

From the commencement of the industrial revolution there has been a fairly direct relationship between national income and the consumption of primary fuels, and estimates of the future demands of fuel and power have been based within fairly wide confidence limits on an extrapolation of this relationship. In industry the maximum utilization of time and resources has not yet been achieved, and big improvements in productivity are possible with a smaller expenditure of mechanical energy than extrapolation from past performance would suggest. Mr. Hicks recognized that we cannot sustain a high industrial output in Britain wholly on our internal resources; neither can we support our economy without importing some oil, particularly for our air and road transport systems, for lubrication and for certain chemical feed stocks. He asked, however, whether it is not a matter for serious consideration whether we should become increasingly dependent for heating and for power generation on imported fuel. In pleading for an increased efficiency in the use of fuels of all kinds, Mr. Hicks pointed out that it is too facile to assume that merely by switching from one fuel to another an automatic improvement in efficiency will result. All fuels, both primary and secondary, require close attention to the choice of equipment and to the operation. It is far less costly, ton for ton, and takes far less time to save coal than to create a new pit.

In his lecture on "Gas", Sir Harold Smith (of the Gas Council) emphasized that the industry is passing through a period of change, perhaps the most important in its whole history. It is facing two new challenges, one due to the increasing shortage of suitable fuel and the other from nuclear power, and is meeting these challenges by basic experiments from which a new gas industry may be developed. New types of coal and new materials are being investigated, and in particular the high-pressure–high-temperature gasification of small, low-quality coal. The collection and distribution of methane from mines and from catalytic plants should make a further useful addition to the supplies available, and he particularly emphasized the interest being taken in the importation of liquid natural gas from America. A thirty-thousand ton tanker would be capable of carrying the equivalent of two million tons of coal. Gas has advantages as an industrial fuel due to its ease of control and the very wide range of temperature which can be obtained.

In the discussion, Mr. D. P. Welman (North Western Gas Board) envisaged the transformation of the existing industry into a truly chemical one, and mentioned the experiments of the North West Gas Board in the development of the hydrogenation process which, if as successful as appears probable at the moment, may well revolutionize the whole industry. The preliminary work will take some four to five years, and a further three or four years will be required to construct a large-scale plant. He concluded by claiming that the gas industry uses coal more efficiently than any other major industry does.

"Nuclear Power" was discussed by Mr. P. T. Fletcher (United Kingdom Atomic Energy Authority). Broadly speaking, the capital cost of the present plant is three times that of a conventional coal-fired generating station. The fuel costs, however, are about a half, so that there is not very much to choose for base load operation between the cost of power generated in the two ways. If, however, the bigger and more advanced stations which are envisaged materialize, the cost per unit of electricity generated from nuclear energy may fall as low as 0·4*d*. per unit. A point of great importance in connexion with nuclear power stations is the load factor, which is more important than with coal. So far as the gas-cooled reactor is concerned, the three main lines of development are an increase in the temperature of the gas leaving the reactor, the design of the fuel elements so that heat is transferred to the gas more effectively—thin rods stacked in clusters in uranium oxide were suggested in this connexion—and reduction in capital cost by simplification of lay-out. Considerable interest was expressed in the future of the boiling-water reactor using enriched uranium or plutonium as the fuel, a system which, it was suggested, would result in marked reductions in the initial capital cost. Mr. Fletcher expressed the opinion that it is justifiable to spend £40–£50 million on experimental work when the potential saving might exceed £200 million. The cost of a prototype plant from the initial laboratory stage is of the order of £20 million, and he believed, therefore, that two such prototypes may justifiably be designed. In the discussion, Mr. M. Zvegintzov (National Research Development Corporation) stated that about twelve times as much money is being put into research in connexion with atomic energy as into all other fuel projects, and asked what the coal or gas industries could do if they had the £50 million for development purposes which Mr. Fletcher suggested for nuclear power. It is still, in Mr. Fletcher's view, very difficult to predict the next stage of development, and even the present programme of research and development will take many years to complete. He was sure, however, that the present United Kingdom pattern of nuclear development was justifiable both economically and technically.

The lectures on "Electricity", by Mr. T. E. Daniel and Mr. A. O. Johnson, were devoted, in the main, to a consideration of its use in electro-heating. It was pointed out that the consumption doubles every ten years, and the view was expressed that the future trend of price should tend increasingly to favour electric energy. The largest single user in Britain is the steel industry, but it was suggested that electrical heating would eventually displace fuel-fired furnaces both for the melting and annealing of glass, and in the ceramic and refractory industries. Advantages of electric heating are its flexibility, the possibility of thermal storage, so far as space heating is concerned, and the extent to which, by adequate instrumentation, its utilization could be rendered automatic. In modern conventional power stations an efficiency of 35 per cent can be obtained, and by a marked increase in size 37–38 per cent would not be unreasonable. Both in the lecture and discussion the possibility of extended use of the heat pump was mentioned, which, in the view of Mr. Frank Rostron (Ferranti Ltd.), has great possibilities when it can be built into the structure.

The final session was devoted to a general discussion with particular reference to future trends. Mr. G. A. J. Begg (Imperial Chemical Industries Ltd.) dealt with the chemical industry and gave figures illustrating the marked economies which have been achieved during the past forty years ; despite these figures, the curve has not yet become asymptotic and further economies may reasonably be expected. Much depends on the elimination of heat losses by the use of waste-heat boilers and in general the recovery of low-grade heat. The siting of factories in relation to generating stations is an important point, as is the private generation of electricity in industry. the three such main producers being the chemical industry itself, the iron and steel industry and paper-making. In small plants oil has great advantages, but throughout capital cost is a basic factor.

The metallurgical industries were discussed by Dr. T. P. Colclough (British Iron and Steel Federation), who pointed out the astonishing economies in fuel which have been achieved in the past thirty years. In 1927, the consumption amounted to 55 cwt. per ton of finished steel ; this had been reduced in 1957 to 28·5. Sintering, the recovery of waste heat, the effective use of blast furnace and coke-oven gas and oil firing have been the major reasons for this. The use of oxygen in the open-hearth furnace to increase the rate of combustion and therefore of refinement is a comparatively new technique, which may well have very marked future influence. In this connexion there is a vast new field in the pneumatic (Bessemer) processes which, with tonnage oxygen available, are opening up a new era.

The trends in general industry were discussed by Dr. W. A. Macfarlane (National Industrial Fuel Efficiency Service), who said that in the past ten years the increase in the energy used in Britain in general industry has been about 40 per cent, and attention was directed to the relatively enormous economies which could be effected by more careful attention to the factors leading to increased efficiency. He believed that 20 per cent of the fuel used could thus be saved.

One may, in conclusion, quote some words of Sir Raymond Street, spoken at the conclusion of a series of meetings on "Science and Industry", arranged by the Manchester Chamber of Commerce in 1944, to which Mr. Hicks made reference : "If you came to this meeting hoping to have a simple answer served up on a platter, you will be disappointed. You have to wrestle with this matter each for himself. Heavy reading, hard study, anxious thought, persistent inquiry, costly experimentation—these are unavoidable and you will drop behind if you cannot stand the pace. It is going to be a difficult, testing life after the war, but full of interest and reward for those that can take it". It is now more than fourteen years since these words were spoken, but they still apply, and particularly so in respect of the problems of fuel and power.

F. C. Thompson

THE LIBRARY ASSOCIATION

CONFERENCE AT BRIGHTON

THE papers presented at the annual conference of the Library Association at Brighton during September 23–26 ranged over a wide field, but the two of most direct interest to the scientist are those in which Mr. W. L. A. Saunders, deputy-librarian, University of Sheffield, discussed current problems of university libraries, and Mr. C. H. Wright, county technical librarian, Hertfordshire, those of special libraries.

Prof. Raymond Irwin in his presidential address reviewing the work and technique of librarianship, including committee work and the place and value of conferences, insisted that librarianship was all directly and closely connected with books and their proper use. The librarian's first responsibility was to help others to read or to find information. His second responsibility was to read himself: to read intelligently, systematically; widely but not aimlessly; with understanding, with sympathy and with appreciation. No routine should be tolerated which hindered rather than helped the discharge of these responsibilities, and Prof. Irwin urged an honest and unprejudiced review of all routines. Books, he insisted, were never more alive than to-day: there was no substitute for the book and there never would be. Finally, insisting on the importance of the librarian himself and the limitations of administrative and bibliographic techniques, Prof. Irwin said that British librarians and librarianship were to-day being exported to Australia, Africa, the Middle East, Canada, the Caribbean and the United States, but there was grave need to increase the export of British books, particularly scientific and technical books, to many parts of the world besides Pakistan. With these books must go British ideas about books and about librarianship, and he hoped we would continue to send out both British librarians and British-trained librarians.

Mr. Saunders said that the main problem facing universities and university librarians at present arises from the increase in the student population, from 50,000 in 1939 to 90,000 at present, with at least 124,000 expected by 1965. At Sheffield it had risen from 767 in 1939 to about 2,000 in 1952, and early this year a target of 4,500 was set. The increase had already set a severe strain on storage space and seating accommodation in many libraries, and the latter was aggravated by the fact that a relatively small proportion of students lived in halls of residence. Few university libraries held excessively large collections, but several were near the 400,000 and 500,000 marks, and in twenty or thirty years many provincial university libraries were likely to approach a million volumes. Collections of this order could daunt new students, and the problem of providing an adequate introduction for an annual intake of several hundred students was serious. In addition to an introductory tour, Mr. Saunders suggested that all undergraduates should at least be made aware of the bibliographical tools of their own field. The whole question of departmental libraries required objective review, and finally he stressed the importance of providing a reasonable salary scale for non-graduate staff so as to attract those capable of relieving the graduate staff of work which did not require high academic qualifications.

Mr. C. H. Wright, pointing out that the special library in the past was chiefly concerned with the flow of information, whereas the public and university libraries were concerned with the flow of books, said that with the vast expansion of scientific and technical literature, the mechanics of organizing the flow of information had become as important to the special librarian as the degree of subject knowledge, while the increasing demand for scientific, technical and commercial information had made the public librarian more aware of the value of specialized subject knowledge. There was thus a better understanding of what are the common foundations of librarianship. After reviewing the problems of staffing a special library and suggesting that more attention should be given to the question of providing suitable training, Mr. Wright said that the present national system of co-operative loan service did not meet all the day-to-day requirements of the industrial or commercial library, and while the National Lending Library for Science and Technology might solve many problems, it appeared likely to be many years before its service could be put to the test. All the investigations made had illustrated the need for local information services and liaison between all the parties concerned. Local schemes of co-operation, however, required a few paid servants to implement policy if co-operation was to be effective. Mr. Wright thought that it was a pity that, in spite of its vital interest in the free flow of information, the Department of Scientific and Industrial Research should be unable to offer financial support to areas where librarians were anxious to co-operate but unable to provide the necessary staff. Such support should be conditional on industry and local authorities continuing to provide an adequate flow of scientific and technical literature. Finally, he referred to the opportunity for a co-operative research organization capable of producing more efficient microtext readers, information retrieval units, and simple photocopying apparatus.

In the course of a paper reviewing the publications and catalogue service of H.M. Stationery Office, Mr. P. McGrath, director of publications, said that the Stationery Office had again been reviewing its catalogue practice and had decided to initiate informal discussions with representative librarians with the view of achieving a compromise which might yield a catalogue more suited to modern requirements. Mr. G. A. Carter, borough librarian of Warrington, in a paper reviewing capital expenditure on building, included both public libraries and school libraries and also libraries in industry (but without giving costs) and in universities, where the estimated cost of five new library buildings due for completion next year was £1,925,000, roughly equivalent to the total expenditure on all new public library buildings in the past twelve years, although in all fourteen university libraries the book stock had increased by only 1·5 million compared with 24 million in public libraries. Mr. Carter also cited figures showing the extreme variation in expenditure on libraries by different local authorities, and he, too, insisted that the new National Lending Library for Science and Technology would not dispense with the need for technical libraries in the municipal and county library systems.

In a stimulating paper of some general interest, Dr. J. Trenaman, liaison officer for further education, British Broadcasting Corporation, under the title "Libraries as a Social Force", described a survey of opinion towards broad educational ends, from which he concluded that about 55 per cent of those in the sample were at least receptive to new and even unwelcome ideas, while the remaining 45 per cent were resistant, at least to the extent of avoiding unaccustomed ideas or not being interested. This resistant sector had usually received only an elementary early education, whereas those who were interested in education had had a fairly good early education, about half having been to a secondary school. They were interested in the more serious radio and television programmes and were also members of a library. There was an upper level of 25 per cent of the whole sample who had mostly received a grammar school education, with a keen interest in further learning and who would be the more serious readers in the libraries. Dr. Trenaman believes that the machinery of education as a whole operates selectively, and accordingly the chief responsibility for adult education rests upon the informal agencies, especially the public library service, the Press and the broadcasting authorities because they have an access denied to all other information agencies. He also emphasizes the profound and durable influence of our early education.

EFFECTS OF PLANT DECOMPOSITION PRODUCTS IN THE SOIL

THE inhibitive effects, on the germination of seeds and on seedling growth, of products from decomposing plant materials in soil have been examined by Z. A. Patrick and L. W. Koch (*Canad. J. Bot.*, 36, 621; 1958). Substances capable of inhibiting the respiration, germination and growth of tobacco seedlings were obtained after residues from timothy, corn, rye or tobacco plants had been allowed to decompose under appropriate conditions in the soil. Bio-assay tests, based on manometric methods, made it possible to determine some of the conditions under which the decomposition gave rise to phytotoxic by-products and to obtain rapidly an accurate measure of the degree of their toxicity.

Among the factors affecting the production of the toxic products, the species and stage of maturity of the plant material added, the water content and *p*H of the soil, and the length of the decomposition period, were the most important. Substances capable of reducing the respiration of tobacco seedlings by 50–90 per cent were consistently obtained when any of the plant residues examined had been decomposing for 15–25 days under conditions of high soil moisture and a *p*H value of the soil solution below 5·5. Timothy yielded substances with the highest toxic activity, followed by corn, then rye, and finally, tobacco. Aqueous extracts of unamended soil or of macerated tissues, prepared either before decomposition or when decomposition was inhibited by autoclaving, were not toxic. The toxic substances, obtained by water extraction, showed an inhibiting effect on respiration of tobacco seedlings after an exposure of less than one hour and also induced darkening and necrosis of root cells. Some extracts affected the cells of the apical meristem most severely while others affected only the cells of the elongation region.

The toxic substances have not yet been identified, but they were relatively non-specific in their action, affecting several test plants in approximately the same manner. Many of them possessed antifungal activity. They were soluble in water, insoluble in petroleum ether, stable in acid, and most active in the *p*H range 4·5–5·8. They were precipitated by alkali and their activity was markedly reduced when they were readjusted to the acid-range. They were also stable to heat and did not lose their activity in storage at 1–3° C. provided they were covered by a layer of toluene. Because of their rapid production and their marked injurious effects on various plants, the authors consider that these toxins may be important under field conditions as the primary factor in some root rots and in predisposing plants to attack by organisms not normally regarded as being pathogenic.

THE NATIONAL INSTITUTE OF AGRICULTURAL BOTANY

THE report for 1957 of the National Institute of Agricultural Botany has recently been published*. The Trials Branch of the Institute has, as usual, carried out an extensive programme of work and the performance of a large number of varieties of the main agricultural and horticultural crops has been assessed. A very special requirement of sugar beet varieties is resistance to bolting, and the results are given of a special series of early-sown sugar beet trials designed to test resistance to premature flowering. The new variety from the Cambridge Plant Breeding Institute, known as Cambro, gave less than 1 per cent of bolters compared with commercial varieties where the percentage varied from 5 to 20. The potato trials have included for the first time a number of foreign varieties from the Continent and North America. The work of the Seed Production Branch has continued to expand, and as well as administering the various field approval and seed certification schemes the Branch has intensified its inquiries into problems of seed production.

The report covers the first full season of operation of the national scheme for the comprehensive certification of herbage seeds. In launching a scheme covering 25,000 acres in its first season, the certifying authority needed, and was fortunate to receive, the full and willing co-operation of all participants. Some 824 growers and 93 merchants took part in the production of 53,500 cwt. of British certified seed. With the co-operation of the Seeds Branch of the Ministry of Agriculture, Fisheries and Food, check samples were drawn from most lots of certified seed and have been tested and then grown in plots for verification purposes. The Official Seed Testing Station received a very similar number of samples in the year under review compared with the previous year, but the proportion of cereals to clovers and root and vegetable samples was much greater because of the very different weather conditions experienced in the two years. The number of samples of each variety of cereal received for testing is some indication of the relative popularity in the country as a whole, and this information is summarized in a table. A notable feature is the disappearance from the list of four old-established varieties, Squarehead's Master, Wilma, Holdfast and Minister. Among the barley varieties, the proportion of Proctor has further increased. The report refers to a number of building developments, including extension to the main building, a cold store and a new glass house.

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* National Institute of Agricultural Botany. Thirty-eighth Report and Accounts, 1957. Pp. 56. (Cambridge: National Institute of Agricultural Botany, 1958.)

THE COLOMBO PLAN

THE sixth annual report* of the Consultative Committee for the Colombo Plan for co-operative economic development in south and south-east Asia, as usual, is in three parts. The first includes a general review of economic progress in the area and of the task ahead; the second summarizes the position in individual countries; and the third directs attention to some contributions to economic development made under the Plan and summarizes the contribution of technical assistance in particular.

Further progress in economic development in the area is recorded and the growth of *per capita* real income appears to have been maintained in spite of balance of payment difficulties and increased internal inflationary pressures. Agricultural production, as well as industrial and mining output, in general, showed an upward trend, but exports did not keep pace with the expansion of imports; prices of some of the main products of the Colombo Plan countries fluctuated, and as a result of these fluctuations and of higher prices of imports, the terms of trade worsened for many countries in the region.

Several countries in the region have now approved development plans, and all are evolving programmes designed to accelerate development. Experience in 1957, however, has emphasized the risk that the pace of development may outrun the availability of resources, and consequently the implementation of development plans should permit re-phasing to match the resources available. Once again, the report stresses the desirability for the countries of the area to pursue policies which serve to attract capital, domestic and external, into development projects and to assure the effective utilization of such capital. A pointed reference is made to the need for consideration of such factors as apprehensions as to the security of investment, difficulties with administrative and financial procedures and restrictions, and uncertainties about the incidence and weight of taxation, all of which could offset the attractions of the region.

Again, the problems of the different countries vary considerably, and accordingly the methods of meeting their needs vary widely also. This is brought out particularly in technical assistance, where some countries need help mainly in the shape of highly qualified missions specially equipped to deal with the planning or implementation of major projects, while others seek quite simple skills. It is important that technical assistance should fit the individual needs of each country, and continuing care is required to ensure that technical resources are not wasted. Continual reference is made in the report to the search by the countries of the area for additional resources, more capital, more equipment, and more managerial and technical skill. Although there are signs of strain in some of the more highly developed as well as in the less-industrialized countries, the situation is not regarded as discouraging, because there are signs that the urgent tasks of development and the raising of living standards are being tackled with speed and energy.

Since 1950, training has been extended to about 13,000 trainees from countries of the area, while about 6,000 experts have been provided by Colombo Plan members and United Nations agencies. Australia alone has contributed £3,440,019 to technical assistance, and during 1956–57 spent £5 million on capital and technical assistance, including £200,000 on technical equipment. Another 439 trainees were received and sixty new appointments of technical experts were made, bringing the total in the field in June to sixty-six. Canada's contribution to capital projects and technical assistance amounts to 196·7 million dollars, of which 34·4 million will be for 1957–58, and more than 4 million dollars (1·4 million dollars in 1956–57) on technical assistance. Since 1951, 712 fellows and scholars have been trained in Canada, and 201 of these were still there in June 1957, while 100 experts have been sent abroad, of whom 35 are at present carrying out assignments in seven centres. New Zealand's contribution for capital and technical assistance will amount to £7 million by June 1958, expenditure on technical assistance totalling £744,000 by June 30, 1957, under which training had been provided for 459 persons (148 in 1956–57) and 72 New Zealand experts provided (16 in 1956–57).

The United Kingdom has since 1951 made available to countries in the area, by way of grants, loans, credits and technical assistance, £92 million, including £2·7 million for technical co-operation up to June 30, 1957, with forward commitments of £1,275,000. Of this, £862,540 has been for research and training equipment, with further commitments of another £786,895. By June 1957, 1,582 trainees had been taken, including 333 from non-Commonwealth countries, and in collaboration with the United Kingdom steel industry and the Government of India up to 300 Indian steel workers are to be trained in the United Kingdom for managerial and technical posts at the new steel works at Durgapur. Of 263 experts provided by the United Kingdom, 23 have gone to non-Commonwealth countries. United States Government economic and technical assistance to Colombo Plan countries during the year totalled 900 million dollars, bringing the total since 1950 to more than 3,000 million dollars. During the year, more than 1,000 technicians and students were taken to the United States under the Mutual Security Programme and 500 sent to third countries such as Japan and the Philippines, while about 550 were taken to the United States under the United States International Educational Exchange Programme. Representatives of sixteen nations of the Colombo Plan Consultative Committee met as a working group in Washington to discuss the United States offer of assistance for establishing a regional nuclear centre to serve the needs of the participating countries.

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* Colombo Plan for Co-operative Economic Development in South and South-East Asia. Sixth Annual Report of the Consultative Committee, Saigon, Viet Nam, October 1957. Pp. 166. (Cmnd. 315.) (London: H.M. Stationery Office, 1958.) 6s. net.

Summarizing the contribution made by technical assistance, the report recognizes that the world scarcity of technical man-power must limit the supply available for the Colombo Plan. By June 30, 1957, expenditure on technical assistance was more than £8 million, including £1·8 million on equipment, and 1,858 persons were receiving training, although the number of new training places declined from 1,552 to 1,395. At the end of the year about 1,400 experts were assigned to countries of the area. Stress is laid on the scope for help from outside the area in developing adequate training institutions, although success depends primarily on the initiative of the institutions themselves, and also on the encouraging increase in the number of countries in the region now providing training places to other countries in the region (Ceylon, India, Indonesia, Malaya, Pakistan, Thailand and Singapore) as against three countries in the previous year. The technique of team work is being used to an increasing extent and within the United States programme some thirty contracts have been arranged with universities of countries within the area to help them develop curricula, teaching methods and research facilities as well as adequate laboratories and libraries.

INTERACTION OF FORMALDEHYDE AND TETRAHYDROFOLIC ACID AND ITS RELATION TO THE ENZYMIC SYNTHESIS OF SERINE

By Dr. R. L. BLAKLEY

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THE reaction between glycine and formaldehyde to form serine in the presence of an enzyme from liver[1] requires, as a co-factor, tetrahydrofolic acid (FH_4, I), which is believed to act by forming a reactive complex with formaldehyde. The structure of the 'active formaldehyde' was first postulated as N^5,N^{10}-methyleneFH_4 (III) in 1954[1], although N^5-hydroxymethylFH_4 (II) is also a possible structure[2]. Formaldehyde is bound strongly by 1 : 2-diamines with the formation of bridged structures. Thus it was demonstrated that N,N′-diphenylethylenediamine reacts readily with formaldehyde to give a stable cyclic product[3]. It might be expected, therefore, that FH_4, which is also a 1 : 2-diamine, would react with formaldehyde to give III, and that this compound would be stabilized to oxygen by the presence of the firmly bound methylene bridge. Although the product of formaldehyde reaction with FH_4 was found to be somewhat more stable than FH_4 itself, it was nevertheless very sensitive to oxygen, for in aqueous solution it rapidly lost coenzyme activity when shaken under air[3]. This sensitivity to oxygen has been confirmed by spectrophotometric studies. When a solution of FH_4 is diluted with phosphate buffer (*p*H 7·2) to a concentration of 5×10^{-5} *M* the spectrum changes within a few minutes from that of FH_4 ($\lambda_{max.}$ 298 mμ) to that of oxidized products with $\lambda_{max.}$ at shorter wave-lengths (finally 275 mμ). If the diluent contains formaldehyde the rate of change due to oxidation is less, but even in the presence of 10^{-3} *M* formaldehyde it is about 3 per cent of that occurring in absence of formaldehyde. In this laboratory, paper chromatography of reaction mixtures has yielded no clear separation of a product with R_F different from that of FH_4 as reported by others[4].

These results were at first interpreted as indicating that II must be the structure of the product, and that it must readily dissociate[3,5]. Investigation of the binding of formaldehyde labelled with carbon-14 by FH_4 and related hydropteridines indicated that approximately one molecular proportion of formaldehyde was bound by FH_4, smaller amounts by N^{10}-formylFH_4 and 2-amino-4-hydroxy-6-methyltetrahydropteridine and a negligible amount by leucovorin[5]. These results have been confirmed and extended by determination of the formaldehyde concentration in equilibrium with known concentrations of hydropteridines. Since tetrahydropteridine is rather unstable, tetrahydroquinoxaline, a close

Table 1. Approximate Dissociation Constants for the Products formed by the Reaction of Formaldehyde with Hydropteridines and Tetrahydroquinoxaline

	Base	Dissociation constant of product = $\frac{[HCHO]\,[base]}{[product]}$
Group *A*	FH_4	0·0004
Group *B*	FH_2	0·01
	N^{10}-formylFH_4	0·01
	N^{10}-methylFH_4	0·03
	2-Amino-4-hydroxy-6-methyltetrahydropteridine	0·04
	4-Hydroxy-6-methyltetrahydropteridine	0·04
	Tetrahydroquinoxaline	0·01
Group *C*	N^5-formylFH_4 (leucovorin)	0·41
	N^5-formyl-4-hydroxy-6-methyltetrahydropteridine	0·45

structural analogue, has also been studied. The results are given in Table 1.

The last two compounds of group *B* are substances which contain only heterocyclic nitrogen, and may be presumed to form hydroxymethyl groups by reaction with formaldehyde. The similarity of the dissociation constants for the products formed by all members of this group suggests that hydroxymethyl groups are formed in all cases, and this is in accord with the fact that methylene bridge formation is precluded in N^{10}-formylFH_4 and N^{10}-methylFH_4.

The very high dissociation constants of complexes formed by group *C* compounds in which a formyl group is substituted on the N^5 position may be interpreted to indicate that N^5 is the essential site for formaldehyde combination with hydropteridines (as previously postulated[5]) and that no other single grouping in leucovorin (for example, N^3, N^8, N^{10} or 2-amino) can provide a strong binding site for formaldehyde. This is in contradistinction to recent hypotheses of multiple binding sites in FH_4 for formaldehyde[4]. It also indicates that N,N′-diphenylethylenediamine cannot be considered a true model for FH_4 in its reaction with formaldehyde. However, the unparallelled combination of formaldehyde with FH_4, in which both N^5 and N^{10} are unsubstituted, suggests that in this molecule both these sites are concerned with formaldehyde binding; since only one molecular proportion of formaldehyde is bound, it seems probable that methylene bridge formation occurs.

Another possible explanation of the relatively high dissociation constants of the complexes formed by formaldehyde with group *B* bases concerns the protonation of the N^5-amine group. In these compounds the N^5-amine group might have a *pK* high enough to result in significant protonation at *p*H 7 and it might be this protonation of N^5 which prevents the reaction with formaldehyde from proceeding to completion. In FH_4, on the other hand, the N^5-amine group may be assumed to have a *pK* well below 7, and thus to be unprotonated at this *p*H. This possibility was tested by determination of the *pK* values of the N^5-amine and 4-hydroxy groups of 4-hydroxy-6-methyltetrahydropteridine. Two groups with *pK* values of 10·2 and 4·1 were detected. The similarity of these to the *pK* values of 9·86 for the hydroxy group and 3·57 for the 5-amino group in the related 4,5-diamino-6-hydroxypyrimidine[6] indicates that in 4-hydroxy-6-methyltetrahydropteridine the *pK* of the N^5-amine group is 4·1. Spectrophotometric studies indicated that no groups in 4-hydroxy-6-methyltetrahydropteridine had a *pK* between 4 and 10. Moreover, no increase in formaldehyde binding occurred at *p*H values above 7. Since differences in the *pK* of the N^5-amine group cannot, therefore, account for the difference between the dissociation constants of group *B* complexes and that of the FH_4-complex, methylene bridge formation in the latter is clearly indicated.

Studies of the rate of reaction of 4-hydroxy-6-methyltetrahydropteridine (4×10^{-3} *M*) with formaldehyde (4×10^{-4} *M*) indicated that equilibrium was reached in a few minutes. Binding of formaldehyde by FH_4 (both at an initial concentration of 4×10^{-4} *M*) was also rapid—80 per cent of the formaldehyde reacting in the first minute. This rate of combination far exceeds those which have been attained for enzymic synthesis of serine, so that enzymic catalysis of the combination appears unnecessary and in fact did not occur with partially purified preparations of serine transhydroxymethylase.

Table 2. ABSORPTION SPECTRA OF FH_4 (5×10^{-5} *M*) IN PRESENCE OF 2,3-DIMERCAPTOPROPANOL (10^{-3} *M*) PHOSPHATE BUFFER *p*H 7·0 (10^{-1} *M*) AND VARIOUS CONCENTRATIONS OF FORMALDEHYDE

Formaldehyde concentration *M*	$\lambda_{max.}$ (mμ)	$\varepsilon_{max.}$ (mol.)
0·0	298	28,400
$6 \cdot 67 \times 10^{-5}$	297	29,000
$1 \cdot 5 \times 10^{-4}$	296	30,800
10^{-3}	294	32,000

The combination of formaldehyde with the bases in Table 1 has also been studied spectrophotometrically. FH_4 and the last three compounds of group *B* show definite changes in spectrum in the presence of formaldehyde. Group *C* compounds, FH_2 and N^{10}-formyl-FH_4, show little or no change in spectrum when formaldehyde is added. Group *C* and the last two compounds of group *B* are relatively stable to oxygen and when kept in aqueous solution under air their spectra changed little (group *B*) or not at all (group *C*) over a period of several hours. Other hydropteridines can be protected from oxidative degradation by sulphydryl compounds, the most efficient of which is 2,3-dimercaptopropanol. This is considerably superior to mercaptoethanol and to mercaptoacetic acid; at a concentration of 5×10^{-3} *M* it stabilizes FH_4 (5×10^{-5} *M*) for many hours, and a concentration of 5×10^{-4} *M* is sufficient to stabilize FH_4 for spectrophotometric measurements.

Representative data for spectra shown by FH_4 in the presence of 2,3-dimercaptopropanol at *p*H 7 are shown in Table 2. The higher the initial formaldehyde concentration the greater was the value of the molecular extinction observed, until a maximum value of 32,000 was obtained in the presence of 10^{-2} *M* formaldehyde. There was also a slight shift in the wave-length of the absorption maximum, from 298 mμ in absence of formaldehyde to 294 mμ in the presence of 10^{-2} *M* formaldehyde. No evidence was obtained for the formation of complexes with absorption maxima at 290–293 mμ, as recently claimed[4].

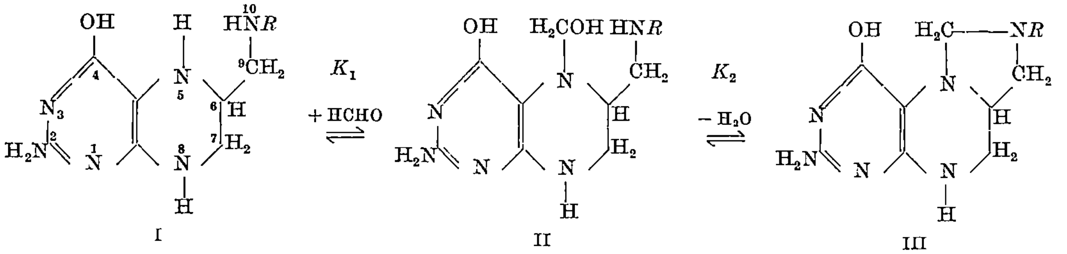
The variation in the wave-length of the absorption maximum and in the extinction coefficient with formaldehyde concentration is believed to be due to the reversibility of the reaction of FH_4 with formaldehyde, rather than to the formation of a series of different complexes[4]. Evidence for this conclusion was obtained by studying the effect of bisulphite on the spectrum of FH_4. The spectrum of FH_4 (5×10^{-5} *M*) in the presence of phosphate buffer *p*H 7 (10^{-1} *M*) and 2,3-dimercaptopropanol (10^{-3} *M*) did not change at an appreciable rate on addition of sodium bisulphite (final concentration $3 \cdot 3 \times 10^{-4}$ *M*). If formaldehyde ($1 \cdot 5 \times 10^{-4}$ *M*) was first added to the solution of FH_4 and the reaction allowed to proceed to equilibrium as shown by the spectrum change, addition of sodium bisulphite then produced a rapid reversal of the spectrum change. This may be interpreted as being due to the dissociation of methylene-FH_4 as a result of the reaction of formaldehyde with bisulphite. Nine extinction values for FH_4 solutions (5×10^{-5} *M*) equilibrated with various concentrations of formaldehyde have been used to calculate the dissociation constant of the complex. A value of $4 \cdot 79 \pm 0 \cdot 30 \times 10^{-5}$ *M* was obtained at *p*H 7·2.

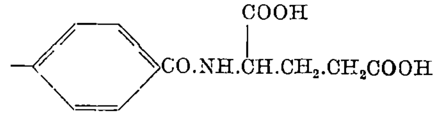
As expected, the time for attainment of equilibrium was inversely proportional to the initial concentration of formaldehyde; in agreement with the results of rate experiments reported above, spectrophotometric measurements showed that equilibrium was established between FH_4 (5×10^{-5} M) and formaldehyde ($6{\cdot}67 \times 10^{-5}$ M) in about 10 min. Reaction in presence of 10^{-2} M formaldehyde was too rapid to measure.

Determination of the dissociation constant for the complex formed by FH_4 and formaldehyde in presence of 5×10^{-4} M 2,3-dimercaptopropanol gave the value $5{\cdot}12 \pm 0{\cdot}16$. The agreement between this value and that obtained in presence of 10^{-3} M 2,3-dimercaptopropanol indicates that at these levels 2,3-dimercaptopropanol does not bind significant amounts of formaldehyde. In the presence of concentrations of 2,3-dimercaptopropanol greater than 10^{-3} M, however, the values obtained for the dissociation constant were high and inconsistent. This is believed to be due to the fact that 2,3-dimercaptopropanol, like other sulphydryl compounds, reacts with formaldehyde and forms a complex with a high dissociation constant, so that significant amounts of formaldehyde are bound only at relatively high concentrations of 2,3-dimercaptopropanol. Evidence that FH_4 and formaldehyde react to form the same final product in the presence of 2,3-dimercaptopropanol as in its absence was found in the fact that 10^{-3} M 2,3-dimercaptopropanol did not alter the spectrum change occurring when 10^{-2} M formaldehyde was added to a solution of FH_4 at pH 7.

The failure of others to detect a non-enzymic reaction between dilute solutions of FH_4 and formaldehyde[4] may be due to the use of high concentrations of 2-mercaptoethanol (10^{-2} M), and this may also account for some other discrepancies. In any event, it has been found in this work that 2-mercaptoethanol (Eastman Kodak, at least 92 per cent in sulphydryl form) was ineffective compared with 2,3-dimercaptopropanol in protecting FH_4 from oxidation.

The following scheme is consistent with the results reported above :



where R is 

where the overall equilibrium constant, K, is 2×10^4 M^{-1}. Since N^{10} binds formaldehyde very weakly compared with N^5 (Table 1), II probably occurs as an intermediate in the formation and dissociation of III. By analogy with compounds of group B in Table 1, the dissociation constant of II may be expected to be about $0{\cdot}03$ M, so that K_1 = approx. 30 M^{-1} and $K_2 = K/K_1 = 667$. Hence at equilibrium methyleneFH_4 exceeds hydroxymethylFH_4 by a factor of about 700.

Addition of glycine and serine transhydroxymethylase to a solution of methyleneFH_4 resulting from equilibration of FH_4 (5×10^{-5} M) with formaldehyde ($1{\cdot}5 \times 10^{-4}$ M) in presence of 2,3-dimercaptopropanol (10^{-3} M) at pH 7·2 caused a change of the spectrum from that of methyleneFH_4 to that of a mixture of methyleneFH_4 and FH_4. At high glycine concentrations approximately 50 per cent of the methyleneFH_4 was converted to FH_4, resulting in the same spectrum as that obtained by adding sufficient formaldehyde to FH_4 to produce 50 per cent conversion to methyleneFH_4. As synthetic FH_4 and hence methyleneFH_4 are racemates due to the asymmetric centre introduced at C^6 during hydrogenation of folic acid, it appears likely that transhydroxymethylase catalyses a reaction with only one of the optical isomers. Neither enzyme nor glycine alone changed the spectrum of methyleneFH_4.

When L-serine was added to FH_4 (5×10^{-5} M) stabilized by 2,3-dimercaptopropanol (10^{-3} M) at pH 7·2 (phosphate buffer, 0·1 M) no change occurred. Subsequent addition of serine transhydroxymethylase caused a spectrum change corresponding to approximately 50 per cent conversion of FH_4 to methyleneFH_4. Even at high concentrations of L-serine the reaction did not proceed further than 50 per cent, presumably because the enzyme again catalysed reaction with only one isomer of the synthetic FH_4. Neither enzyme alone, nor enzyme together with D-serine, caused the spectrum change. The spectrum obtained when FH_4 was equilibrated with excess L-serine and enzyme was the same as that produced when sufficient formaldehyde was added to FH_4 to convert 50 per cent to methyleneFH_4. When excess formaldehyde was added to FH_4 which had been first equilibrated with L-serine and enzyme, the final spectrum had the same $\lambda_{max.}$ and extinction coefficient as that resulting from addition of excess formaldehyde to FH_4 alone.

Isolation of ethanol-insoluble barium salts from larger-scale incubations of DL-serine, enzyme and FH_4 gave a product with a spectrum in 0·1 N sodium hydroxide similar to that of methyleneFH_4. When the molecular extinction of the product was determined, however, it was found to be only about half that of methyleneFH_4 ; this is believed to be due to the rapid decomposition during isolation of the unreacted isomer of FH_4 giving rise to contaminating products with little absorption at 298 mμ. The material was active as coenzyme for enzymic synthesis of serine but decomposed in solution to an inactive product. The decomposition was accelerated by shaking in air or oxygen, by increase in temperature and by dilution. Under hydrogen, decomposition was negligible and catalytic hydrogenation restored some coenzyme activity to the decomposition products. The decomposition, like the decomposition of synthetic methyleneFH_4, was dependent on pH, being fastest at about pH 5 and negligible at pH 13. This increased stability at higher pH seems to be due to the ionization of the 4-hydroxy group, since the effect becomes marked in the pH-range in which this group dissociates.

These results indicate that the only difference between synthetic methyleneFH_4 and the product of the enzymic reaction of L-serine and FH_4 is that synthetic methyleneFH_4 is a racemate, whereas the enzymic product is a single stereoisomer. No evidence was found that the non-enzymic reaction of formaldehyde and synthetic FH_4 produced any material of a different chemical nature from that of the enzymic intermediate. Spectrophotometric studies indicated that in the reaction:

$$\text{Glycine} + \text{methylene}FH_4 \rightleftharpoons \text{serine} + FH_4$$

the equilibrium lies to the left, the constant being about 0·3. Although it has been assumed that it is methyleneFH_4 which reacts enzymically, the data are also consistent with N^5-hydroxymethylFH_4 (in rapid equilibrium with methyleneFH_4), being the actual participant in the reaction. The coenzyme activity of FH_2 may be due to the contamination of FH_2 preparations by FH_4. If, however, FH_2 is indeed a coenzyme and if it reacts with formaldehyde to form only N^5-hydroxymethylFH_2 as the value of the dissociation constant seems to imply, then N^5-hydroxymethylFH_2 is capable of reaction with glycine in presence of serine transhydroxymethylase, without mediation of a methylene-bridged compound. By analogy this would suggest that N^5-hydroxymethylFH_4 rather than methyleneFH_4 is the substrate for serine transhydroxymethylase; furthermore, a simple reaction mechanism is possible if this is the case. Enzymic dehydrogenation of the formaldehyde-FH_4 complex to N^{10}-formylFH_4 via N^5,N^{10}-metheneFH_4 (anhydroleucovorin) is more easily conceived as involving methyleneFH_4 as substrate[7].

In the above discussion no mention has been made of the fact that glycine and serine react in the form of Schiff's bases of pyridoxal phosphate. In the spectrophotometric experiments reported here no pyridoxal phosphate was added, but previous evidence indicates that it is firmly bound to serine transhydroxymethylase. It may be assumed that, prior to their interconversion, serine and glycine react with bound pyridoxal phosphate to form Schiff's bases.

I should like to express my indebtedness to Dr. D. J. Brown for generous gifts of pteridines, to Mr. J. McKeough for skilled technical assistance, and to Prof. A. H. Ennor and other members of this Department for helpful advice and criticism.

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SOME NEW VERTEBRATE FOSSILS FROM THE PANCHET SERIES OF WEST BENGAL

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THE Panchet series of rocks form part of the Gondwana System of India, and their age has been a subject of controversy ever since they were first named by W. T. Blanford[1] in 1861. Suggestions have ranged from Upper Permian to Upper Triassic, inclusive. The purpose of this communication is to make a preliminary announcement of some new discoveries of vertebrate fossils from the Panchets which do much to solve the question of the age of these rocks.

The Panchet series occur chiefly in the Raniganj coalfield of West Bengal, where they form a cover to part of the coal-bearing Damudas. The succession of Gondwana rocks in the Raniganj coalfield is:

- Supra-Panchets
- Panchet series
- Damudas
  - Raniganj measures
  - Ironstone shales
  - Barakar measures
- Talchir series

All these rocks were formed under continental conditions during late Palæozoic and Mesozoic times. They accumulated in a depression or valley in a landscale carved out of Archæan rocks, and are themselves largely erosion debris which was derived from neighbouring hilly areas made up of Archæans. The upper part of the Panchet series consists mainly of sandstones with subordinate shales, while the lower part is mainly shales with subordinate sandstone bands. No trace of coal has ever been found in the Panchet series.

In 1860 Dr. Blanford and Mr. Tween discovered some fossils in the Panchet series. Plant remains were found in the lowest beds and were described by Feistmantel[2] in 1880. Of the eleven species described, seven are also found in the underlying Damuda formations. Isolated and fragmentary bones, often rolled and water-worn, were discovered in conglomeratic sandstones in the upper part of the Panchets, where these rocks crop out in the bed of the River Damuda. These bones, usually teeth, fragments of jaws, vertebræ and limb bones, were described by Huxley[3], and later collections of similar material were described by Lydekker[4]. These authors identified a fauna consisting chiefly of labyrinthodonts and dicynodonts. A few years ago, Dr. M. R. Sahni, palæontologist to the Geological Survey of India, asked a field officer, Mr. S. N. Puri, to make a further collection from the conglomeratic Upper Panchet sandstones. Mr. Puri found fossiliferous outcrops at a number of places in the southern part of the coalfield, made an excellent map of these localities, and brought back a collection which included one good roof of a labyrinthodont skull, as well as a large number of isolated bones and fragments. The labyrinthodont is being described by Prof. F. von Huene and Dr. Sahni.

Permo–Triassic labyrinthodonts are only rarely of use in correlation and dating. Some dicynodonts are very useful horizon-markers, but since this group has a considerable uniformity of general structure, while varying a great deal in detailed morphology, it is necessary to have good specimens before a proper assessment of affinity can be made. Dicynodonts are locally common in the Permian *Tapinocephalus* zone of South Africa, in the next, *Endothiodon*, zone they are fairly abundant, and they are exceedingly common and varied in the succeeding *Cistecephalus* zone. In the *Lystrosaurus* zone, though individuals are often abundant, almost all belong to the genus which gives its name to the zone. The genus is not found outside this zone and is therefore an excellent zone fossil. During the rest of the Trias, dicynodonts are restricted to a few genera of large size. Thus, the presence of dicynodonts in the Panchet series does not provide a means of dating these rocks without the more detailed knowledge of these fossils which only good specimens can provide.

In the re-survey of the Raniganj coalfield made in 1925–28[5], some fish scales were found at a single locality in the lower Panchet shales. Among these, Dr. E. I. White identified a scale of *Amblypterus*, and this lends a distinctly Palæozoic aspect to the lower part of the Panchets, as does the character of the flora.

In the autumn of 1957 I went to India as the guest of the Indian Statistical Institute, at the invitation of the director, Prof. P. C. Mahalanobis. At the beginning of December I visited the Raniganj coalfield as part of a programme of field-work which had as its main object the attempt to discover further vertebrate fossils in various formations of the Gondwana System. The rather fragmentary remains found in some of the Gondwana formations, mainly during the past century and usually by amateurs, suggested that the Gondwana System might be potentially as rich in fossil vertebrates as the famous Karroo of South Africa, and apart from the evolutionary interest of any discoveries which could be made, these would also provide a means of correlating and dating the Gondwana formations. Hitherto, correlations have mainly been made on floral evidence, which is not a very satisfactory tool, but which has had to be used in default of anything else.

The field-work on the Panchets of the Raniganj coalfield was carried out as a collaboration between the Indian Statistical Institute and the Geological Survey of India. Three junior Survey officers, Mr. C. Tripathi, Mr. P. P. Satsangi and Mr. S. T. Rajurka, and two palæontological research workers at the Indian Statistical Institute, Dr. S. L. Jain and Mr. T. K. R. Chowdhury, accompanied me into the field. We found that, in the upper part of the Panchet series, conglomeratic sandstone was very fossiliferous in places, but though part of an amphibian skull roof and a few good specimens of individual bones and jaws were obtained, many of the fossils were fragmentary and no associated skeletons were ever found. The reason for this is plain from an examination of the sandstones. They are all highly false-bedded rocks, and in places even contorted. They evidently represent a large delta tip-heap, into which sand, pebbles and animal bones were swept by a river and its tributaries. The sediment sometimes piled up so fast that it became unstable and slumped a little way down the growing delta front. The shales of the lower part of the Panchet series seemed to form lenses of various sizes, the formation of which could be envisaged as due to the gradual silting up of pools and lakes. Under such conditions, land animals dying in or near to the pools would be more likely to suffer burial without dismemberment. We therefore began to search the shales in the lower part of the Panchets, and Mr. P. P. Satsangi was the first to discover in them the skeleton and skull of a dicynodont. The skull could immediately be identified as that of a species of *Lystrosaurus*. Five skulls and some more skeletal remains of *Lystrosaurus* were found, but no other tetrapods so far.

The discovery of a number of good specimens of *Lystrosaurus* in the Panchets allows the immediate correlation of the series with a zone of the Karroo succession in South Africa. The zones of the South African succession, and their dicynodont faunas, are :

Beaufort series :		
Cynognathus zone	*Kannemeyeria*	Lower Triassic
Procolophon zone		
Lystrosaurus zone	*Lystrosaurus* and *Myosaurus*	
Cistecephalus zone	*Dicynodon*, *Cistecephalus*, and other genera with 195 spp.	Upper Permian
Endothiodon zone	*Dicynodon*, *Endothiodon*, and other genera with 27 spp.	
Tapinocephalus zone	*Dicynodon* and other genera with 8 spp.	

Since *Lystrosaurus* has also been discovered in Sinkiang[6], the new discovery in the Indian Panchets is of interest as going some way towards providing a geographical link between Sinkiang and South Africa in the distribution of the genus in early Triassic times.

Only one other associated skeleton of a fossil tetrapod has ever been found in the entire Gondwana System. The previous discovery was made almost a hundred years ago by an Army officer, Major Gowan, who found the skeleton and skull of the labyrinthodont *Gondwanasaurus bijoriensis* at the crossing of a stream by a bullock-cart track some miles south-west of Pachmari. The new discoveries raised hopes about the possibilities in other formations of the Gondwana System, and these hopes have already been realized in field-work done in other areas by me, in collaboration with Dr. Jain and Mr. Chowdhury. The fossils discovered are still under investigation, but comprise skeletons and skulls instead of the fragments previously known. The Gondwana formations can evidently be regarded as a very hopeful source of fossil vertebrate material, and certain formations provide the only possibility of obtaining a continental fauna of Lower to Middle Jurassic age anywhere in the world.

A rather more detailed account of the work done on the Panchets of West Bengal, with a preliminary discussion of the new fossil material, will appear elsewhere, and a detailed description of the new *Lystrosaurus* specimens will be undertaken by Tripathi and Satsangi at the Geological Survey of India.

It is a pleasure to thank Prof. Mahalanobis for the invitation and facilities which made my work in India possible. I am grateful to many members of the Indian Statistical Institute for their help. I should also like to thank Mr. V. P. Sondhi, director of the Geological Survey of India, for much help and friendly co-operation, and Mr. K. K. Datta for facilities in the field.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Stabilization of Water Mists

The stability of a water mist formed in an atmosphere that is not fully saturated is severely affected by droplet evaporation. Thus a water-drop 10μ in radius suspended in air at 20° C. and 80 per cent relative humidity can be shown to have a life of only 2·4 sec. Richardson[1] describes experiments in which no water-drop of radius less than 200μ, dropped from the top of a 40-m. tower, reached the bottom.

The possibility of reducing the coefficient of evaporation of a plane water surface from 4×10^{-2} to 6×10^{-6} by coating it with a monomolecular layer of a long-chain fatty acid has been demonstrated[2], and reductions in the rate of evaporation of the order of 50 per cent have been obtained by means of monolayers of cetyl-stearyl alcohol[3]. Bradley[4] pointed out that, with droplets of Stokesian or smaller size, a corresponding reduction in the evaporation coefficient could be expected to result in a very much greater reduction of the rate of evaporation than with a plane surface. This was shown to follow from a simplified form of Fuchs's[5] equation of droplet evaporation :

$$\frac{dm}{dt} = \frac{-4\pi a w c_0}{1 + (D/a\nu\alpha)}$$

in which dm/dt is the rate of evaporation of the droplet, a its radius, w the mass of a vapour molecule, α the evaporation coefficient, c_0 the saturation concentration of vapour in air, D its diffusion coefficient, and $\nu = \sqrt{(kT/2\pi w)}$, where T is the absolute temperature.

The present communication describes an attempt at producing a water mist each drop of which is coated with a monolayer. This was done by dispersing in the water a mixture of almost equal parts of cetyl and stearyl alcohol in a concentration of 0·2 per cent by weight, using as a dispersing agent 0·1–0·2 per cent of a compound of "fully hardened sperm alcohol and 15 molecules (average) of ethylene oxide". The dispersion is stable and can be atomized. At the low mean droplet radii of the aerosol so generated (mean surface radius 7·5μ) this overall concentration proved sufficient to coat the droplets. This is because the rate of diffusion of water into the air at the droplet surface is about 10^4 times that of the dispersed alcohol into the droplet interior ; once evaporation starts, monolayers of high surface pressure may be expected to form on the surfaces.

To test the efficacy of the monolayers the dispersion was atomized by means of a compressed-air nozzle and introduced into the top of a vertical tube, 1 ft. in diameter and 15 ft. high, the aerosol being sampled during its descent at various levels inside the tube. The vertical tube was kept at a temperature of 28·3° C. and the humidity varied over a wide range. Counts made of the various samples gave droplet size distributions which enabled the rate of evaporation to be calculated as a function of relative humidity. The experiments were repeated with water alone. Fig. 1 shows the variation with relative humidity of the initial radius of droplets, both water and dispersion, that just fall through 12 ft. in these conditions before completely evaporating.

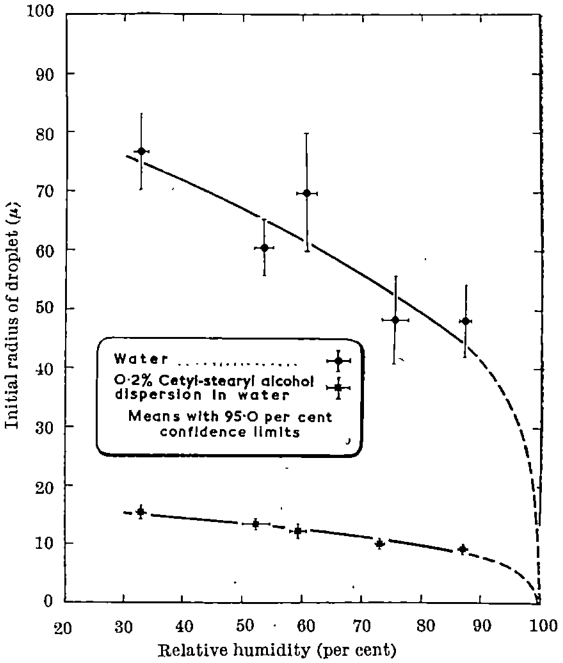

Fig. 1. Effect of humidity on the initial radius of a droplet that falls 357 cm. before completely evaporating. (Crown copyright, S.M.R.E.)

Measurement of the evaporation coefficient of the dispersion gave a minimum value of $1{\cdot}5 \times 10^{-5}$ at high concentrations. Substituting this value in Fuchs's equation, it was found that the latter predicted the rate of evaporation of the dispersion droplets and its variation with relative humidity, within the size-range used, with some accuracy. The equation could thus be used to calculate the total life of the droplets shown in Table 1.

Table 1. Life of Droplet at 20° C. and 80 per cent Relative Humidity

Radius of droplet (microns)	Water (sec.)	Dispersion (sec.)
5	0·64	656
10	2·35	1,314

A considerable increase in the life of a droplet and, hence, stability of mist is thus obtained. In more recent experiments it was found that concentrations of 0·1 per cent of alcohols and of dispersing agent gave results that did not differ significantly from those with 0·2 per cent of these agents.

A more detailed paper is to be published in due course. We wish to thank Dr. T. G. Jones, Research Department, Unilever, Ltd., for suggesting and preparing the dispersing agent and the Ministry of Power for permission to publish this communication.

H. S. Eisner
F. R. Brookes
B. W. Quince

Safety in Mines Research Establishment
(Ministry of Power),
Buxton.

Oct. 7.

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Diffraction Anomaly in Polarizing Microscopes

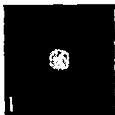
The image quality of the polarizing microscope has never been critically examined, perhaps because the instrument was used primarily for determining optical constants of crystals and fibres, rather than for studying fine details of the object. We have recently re-examined its reliability and find that unless the rotation at the lens surfaces is rectified, the unit diffraction pattern is not an Airy disk but a four-leaf-clover pattern, and that the resolution and contrast may be spurious.

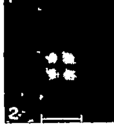
In a conventional polarizing microscope the field between crossed polarizers illuminated by a bright source is never completely dark. If the microscope is equipped with lenses completely free from strain birefringence a polarization cross is observed at the back aperture of the objective lens. The light in this cross is introduced almost exclusively by rotation of the plane of polarization at the oblique interfaces between the polarizer and the analyser[1,2]. The rotation is a consequence of differential transmittance of the vectors polarized parallel and perpendicular to the planes of incidence and may reach 6 deg. or more at the edge of the aperture. This not only lowers the extinction of the polarizing microscope at high numerical apertures, but also modifies the aperture function of the system even when the condenser diaphragm is closed. As a result, the diffraction image of a pin-hole between crossed polarizers is no longer a regular Airy disk (Fig. 1) but a clover-leaf pattern possessing a dark centre and a dark cross (Fig. 2). Its intensity is expressed by :

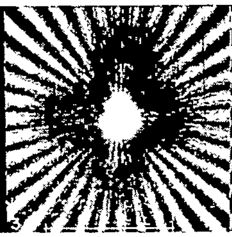
$$I \simeq \sin 2\theta \, J_3(r)/r \qquad (1)$$

where θ and r are polar co-ordinates in the image plane (θ is measured from the plane of polarization of the polarizer and r is measured in diffraction units) and $J_3(r)$ is a Bessel function of the third order.

Densitometry of photographs of sub-resolution pinholes taken through a special strain-free polarizing microscope agrees well with the distribution of intensity calculated from this formula. The special polarizing microscope used for this work was designed jointly by one of us (S. I.) and the American Optical Co. and was constructed at the University of Rochester with generous support from the former. The distribution of intensity along $\theta = \pm \pi/2$ (Fig. 5) shows that the radius of the central maximum in the clover-leaf pattern coincides approximately with the first minimum of the Airy disk. The ratio of the intensity of the central to that of the first diffraction maxima is 10 : 1 in the clover leaf as opposed to 50 : 1 in the Airy disk.







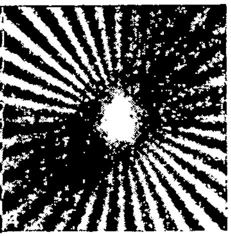


Fig. 1. Airy disk in the absence of a polarizer. The diffraction pattern was obtained by optically reducing a pinhole 20μ in diameter located in front of the lamp to 0·2μ and then re-magnifying. A pair of identical strain-free 97 × oil-immersion objectives with 1·25 numerical aperture was used. The image produced by this system is identical with the image of a 0·2-μ pinhole located at the object space, except that the lens errors are doubled

Fig. 2. As for Fig. 1, but between crossed polarizers. Scale for Figs. 1 and 2, 1·0μ

Fig. 3. Image of a Siemens's test chart between crossed polarizers. Except for the Siemens's star which replaced the pinhole, system identical with that of Fig. 2. Notice reversal of contrast and spurious resolution. Scale for Figs. 3 and 4, 10μ

Fig. 4. Image of same test-chart as in Fig. 3, between crossed polarizers but viewed through the same objectives after they were rectified. The diffraction anomaly has disappeared

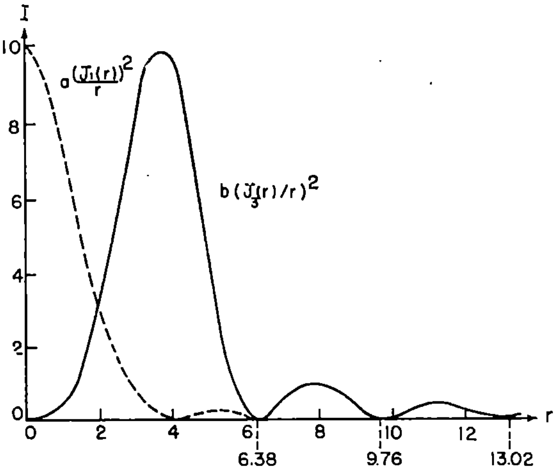


Fig. 5. Intensities (I) of the diffraction image of an unresolved pinhole calculated along the radius (r in diffraction units) at 45° to the plane of polarization. Broken line, Airy diffraction pattern in non-polarized light, or in polarized light with rectified optics. Solid line, with non-rectified optics between crossed polarizers. The curves have been normalized to make the central maxima equal. Microdensitometer tracings of Figs. 1 and 2 agree with the calculated curve to within a few per cent

As the polarizer is rotated away from the crossed orientation the clover leaf changes to a diagonal figure of eight, an ellipse, and finally to the regular Airy disk when the polarizers are parallel. Similar changes are observed when compensators are introduced between crossed polarizers.

When, on the pinhole, a uniaxial crystal is superimposed with its optic axis parallel to the axis of the microscope (Z-cut), the diffraction image of the pinhole between crossed polarizers is again expressed by equation (1) even in the absence of rotation. With parallel polarizers a diffraction image similar to that in an astigmatic system is formed by the extraordinary rays, superimposed on the Airy disk formed by the ordinary rays. These are also the diffraction images of pinholes formed by catadioptric (reflecting) polarizing microscopes without any crystals.

When a crystal is introduced with its axis normal to the microscope axis (X-cut), a highly astigmatic diffraction pattern identical with those reported by Nienhuis for conventional astigmatism is superimposed on the Airy disk. Theoretical formulæ for all these diffraction patterns, except for the X-cut crystal, were calculated by one of us (H. K.) ; they are reported in ref. 3 together with their experimental verifications.

The effect of anomalous diffraction on a periodic absorbing object was determined by observing a black-and-white test chart through a pair of oil-immersion lenses showing a medium degree of rotation. As shown in Fig. 3, contrast reversal and spurious resolution are observed to varying degrees at different orientation of the periodic object.

These diffraction anomalies clearly indicate the danger of using polarizing microscopes or other optical instruments employing polarized light at high angles of incidence[2] without due consideration of the image quality. On the other hand, some of the properties described may be used to advantage for modifying the aperture function and even for obtaining higher 'resolution' in special cases. In general, the Rayleigh criterion of resolving power is not applicable and, instead, it is suggested that the transfer (or response) function of the system be used to evaluate the image.

The diffraction anomalies and the resulting spurious image are practically eliminated with the polarization rectifier[2]. The rectifier corrects the rotation so that the state of polarization is no longer irregular, and a uniformly dark aperture is obtained. Fig. 4 shows the correct image of the same test-chart viewed through a pair of rectified oil-immersion objectives. With rectification, the maximum resolving power of the light microscope can be realized, and the system has been utilized for exact studies of biological objects possessing birefringence down to a fraction of an angstrom unit.

This research was supported in part by grant (*C*-3002-*C*) from the National Institutes of Health, U.S. Public Health Service, awarded to Shinya Inoué, a National Science Foundation grant awarded to Dr. M. Parker Givens, Institute of Optics, University of Rochester, and by the American Optical Company.

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Mosaic Structure of Photographic Emulsion Crystals

CRYSTAL imperfections play an important part in present studies of the formation of the photographic latent image. In large silver bromide crystals it has been shown[1] that silver prints out along individual dislocation lines. Little direct evidence has yet been given on defects within the small grains of photographic emulsions, since neither light microscopy nor electron microscopy has yet proved effective in this field.

It was found by a convergent beam X-ray analysis[2] and by an X-ray microbeam diffraction method[3] that there exist in the grains of some commercial photographic emulsions distinct angular misalignments and sub-structures. In recent studies of X-ray microbeam transmission photographs using a Hilger 'Microfocus Unit' we have now been able to obtain separately resolved structures within the diffraction spots from individual emulsion grains. In some of these spots up to six individual subdivisions can be detected (see Fig. 1*a* and *b*, each of which shows enlargements (×120) of a diffraction spot). Such high-resolution spots were obtained with X-ray tube focal areas of dimensions 4 × 40μ and 100 × 140μ with lead glass capillaries of 10μ diameter as collimators for the incident X-ray beam. As recording material Kodak 'Crystallex' X-ray film was used. Experiments were carried out to show that the grains themselves, and neither the intensity distribution of the focal spot nor the structure of the paper of the envelope of the recording film, is responsible for the effect. This evidence is also supported by the fact that within the same type of photographic emulsion grains different types of characteristic structures of spots can be distinguished within the spotty powder ring. On the other hand, certain other emulsion grains under the same exposure conditions show diffuse diffraction spots (without any sub-divisions) and this effect is probably due to broadening of small crystallites size. (*Note added in proof:* We now have direct evidence that this explanation is correct.)

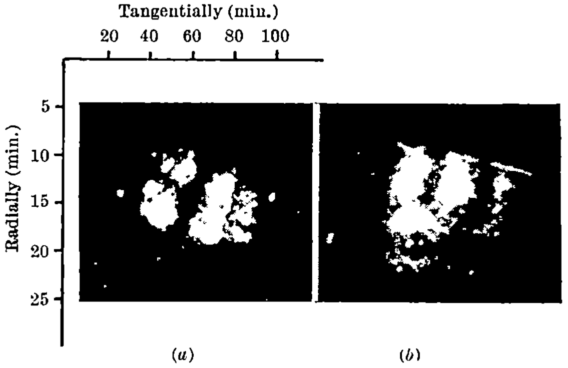

Fig. 1. Enlargements (×120) of diffraction spots taken from a photographic emulsion having grains with a mean diameter of 1μ (*a*) and 1·5μ (*b*). Each group of spots corresponds to a diffraction image of one grain. The scales correspond to the angular displacement of planes in radial and tangential directions

From considerations of the divergence of the X-ray beam, the natural spread of wave-lengths, and the separation of the $K\alpha_1$ and $K\alpha_2$ wave-lengths, it is concluded that the detail within diffraction spots reveals the mosaic structure of the grains. From measurements of the distances between nearest structure elements within diffraction spots it is found that angular misalignments of 3′–4′ between planes are resolved.

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Neutron–Proton Interaction

THE present communication suggests a new approach to the proton–neutron interaction and the deuteron problem. We have been able to calculate successfully the binding energy of the deuteron by the suggested interaction. The approach is phenomenological in that the structure of the nucleons has not been taken into account.

It is proposed that the interaction between the nucleons is magnetic. First let us consider a model based on the old quantum theory. Let μ_p and μ_n represent the magnetic moments of the proton (positive) and neutron (negative) respectively, and let r be the distance between them. Then the minimum potential energy in the attractive case is given by:

$$W = \frac{2\mu_p\mu_n}{r^3} \qquad (1)$$

The spin of the deuteron is 1, which suggests a parallel alignment of the neutron and proton spins, and no orbital motion of the two nucleons about their common centre of mass.

The value of r has to be determined by quantum conditions. Turning to the quantization of length, if M_r be the reduced mass of the system, a highly suggestive fundamental length is $h/2\pi M_r c$.

Then the distance in the nth state is given by:

$$r_n = \frac{nh}{2\pi M_r c} \qquad (2)$$

This expression can be justified in other ways also:

(i) In the Bohr atom model, the expression for the radius can be written:

$$r_n = \frac{n\hbar}{M_r c} \cdot \frac{c}{v} \qquad (3)$$

Under the condition $v \rightarrow c$,

$$r_n = \frac{n\hbar}{M_r c}$$

which is the same as (2).

(ii) The Bohr expression for the radius is:

$$r_n = \frac{n^2\hbar}{M_r c} \cdot \frac{1}{\alpha} \qquad (4)$$

where α is the fine structure constant (1/137·04). Current nuclear theories suggest that for the nucleus the corresponding constant is approximately 1. If we assume that $\alpha = 1$ for the nucleus:

$$r_n = \frac{n^2\hbar}{M_r c} \qquad (5)$$

which is the same as (2) except for the power of n.

Substituting the value of r_n in equation (1), we get:

$$W = \frac{2\mu_p\mu_n M_r^3 c^3}{n^3\hbar^3} \qquad (6)$$

In the following, the values of the magnetic moments and masses of neutron and proton have been taken from the paper by Shapiro[1].

For the ground-state:

$$W = -2\left(\frac{2{\cdot}792743e\hbar}{2M_p c}\right)\left(\frac{1{\cdot}913138e\hbar}{2M_p c}\right)\frac{M_r^3 c^3}{\hbar^3} \qquad (7)$$

First we deduce an approximate expression. Putting $M_r \approx M_p/2$, expression (7) becomes:

$$W = -(2{\cdot}792743)(1{\cdot}913138)\left(\frac{M_p c^2}{16}\right)\frac{e^2}{c\hbar} \qquad (8)$$

With $M_p c^2 = 938{\cdot}21$ MeV., this simplifies to:

$$W = -2{\cdot}286 \text{ MeV.} \qquad (9)$$

Next we calculate W by taking the exact value of M_r. As $M_p c^2 = 938{\cdot}21$ MeV. and $M_n c^2 = 939{\cdot}51$ MeV., $M_r c^2 = 469{\cdot}43$ MeV., and equation (6) gives:

$$W = -2{\cdot}291 \text{ MeV.} \qquad (10)$$

This value is in good agreement with the observed binding energy 2·226 (±0·002) MeV. (Wapstra[2]). However, the discrepancy of 0·065 MeV. is well outside the limits of experimental error. Further, it cannot be explained as due to possible errors in the values of the constants involved, as these are known to a high degree of accuracy.

Either of the equations (2) or (5) may be the correct one. By equation (2), $W \propto 1/n^3$, and by equation (5), $W \propto 1/n^6$.

Using the experimental value for the ground-state energy of the deuteron, the first excited state is indicated at 0·278 MeV. or 0·035 MeV. (corresponding to the two possibilities). No excited state of the deuteron has been reported so far. Should it be at 0·035 MeV., it could have been easily missed due to the fact that the transition energy $(W_2 - W_1)$ would be very close to the disintegration energy. Experiments on this point are highly desirable.

Next we consider the wave mechanical treatment. The present suggestion defines a tensor force and we can put:

$$V = -S_{12}J(r) \qquad (11)$$

where $J(r) = -\frac{\mu_p\mu_n}{r^3}$

and $S_{12} = \frac{3(\sigma_1.r)(\sigma_2.r)}{r^2} - \sigma_1.\sigma_2$

where σ_1 and σ_2 are the Pauli spin operators for the proton and neutron respectively.

Usually a mixture of central and tensor potentials is employed[3]. Christian and Noyes[4] have used a pure tensor force in the investigation of p–p scattering.

Equation (11) is also a pure tensor force. But of course one can speak of an 'equivalent central force' (Christian and Hart, ref. 3).

The states $^3S_1$ and $^3D_1$ would be coupled for the present potential, and, following Rarita and Schwinger[3], it is seen that the radial wave functions for the $^3S_1$ and $^3D_1$ states must satisfy the simultaneous equations:

$$\frac{d^2u}{dr^2} + \lambda Eu - 8^{1/2} \cdot \frac{\lambda\beta}{r^3} w = 0 \qquad (12a)$$

$$\frac{d^2w}{dr^2} + \left[\lambda E + \frac{2\lambda\beta}{r^3} - \frac{6}{r^2}\right] w - 8^{1/2} \cdot \frac{\lambda\beta}{r^3} u = 0 \qquad (12b)$$

where $\lambda = 2M_r/\hbar^2$

and $\beta = \mu_p\mu_n$

These equations suffer from the well-known difficulties associated with r^{-3} singularity. Perhaps a 'cut-off' device[5] will have to be used with 'cut-off' at $\hbar/M_r c$.

In view of the fact that in the case of the hydrogen atom results on the basis of old quantum theory and wave mechanics are nearly the same, it may be that for the deuteron also the situation is not very different.

The quadrupole moment of the deuteron is expected to be of the order of r_1^2. With the value of r_1 given by equation (2):

$$Q \sim r_1^2 = 1{\cdot}764 \times 10^{-27} \text{ cm.}^2$$

This may be compared with the experimental value

$$Q = +2{\cdot}73 \times 10^{-27} \text{ cm.}^2$$

There is also the possibility that the interaction may be a combination of a central force and the magnetic tensor force, but the tensor force alone may be responsible for the binding. It may be mentioned that interesting analogies between magnetostatics and the pseudo-scalar meson field have been drawn by Kahana and Coish[6].

Further details of the investigation are to be published later.

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An Artificial Aurora

IN a recent communication[1] conclusive evidence has been presented for the artificial production of auroral phenomena by the detonation of a nuclear device in the upper atmosphere. The auroral display in question was observed at Apia Observatory, lat. 13° S., long. 171° W., and is considered to have been produced by a nuclear bomb exploded approximately one hundred miles above Johnston Island, lat. 17° N., long. 169° W.

The distance between Johnston Island and Apia is about 2,200 miles, and hence an explosion 100 miles above Johnston Island could not be seen from the upper atmosphere over Apia. Thus direct radiation from the explosion could scarcely be the cause of the observed aurora. On the other hand, as undoubtedly will have occurred to many people, if a nuclear explosion is produced high enough in the atmosphere, charged particles emitted as a result of this explosion could be guided along the lines of force of the Earth's magnetic field and returned to Earth at a point on the same geomagnetic longitude and opposite geomagnetic latitude. While there will be a small eastwards drift across the lines of force due to the vertical gradient of the Earth's field, it will be only of the order of 100 metres, the exact magnitude depending upon the angle of pitch of the particle's trajectory. Since the geomagnetic equator at a geographic longitude of 170° W. is situated at about 3° N., and the declination in this region is about 10° E., it can be seen that Johnston Island and a region to the north-west of Apia do approximately fulfil these conditions of lying on the same line of force.

In a nuclear explosion, electrons and charged ions will be produced. The electrons will have β-ray decay energies of up to a few million electron-volts and thus, neglecting electrostatic forces, will readily be able to escape from any residual matter above the point of detonation and, on their return to the atmosphere, be able to produce effects at relatively low altitudes. Therefore, it seems that these β-ray electrons can adequately explain the observed phenomena. The charged ions produced at the same time would appear in general not to have sufficient energy to enable them to escape from the region of the explosion.

The duration of the auroral display was between six and seven minutes. The transit time for β-rays between Johnston Island and Apia along a line of force would be only a few hundredths of a second, and for β-rays of lower energy moving in spirals around the lines of force with very small angles of pitch can scarcely exceed a few seconds. However, there appear to be at least two mechanisms operating which explain the long time-scale of the aurora. First, the average life-time of nuclei produced in nuclear explosions which decay by β-emission is of the order of minutes, and, secondly, large numbers of atoms in the upper atmosphere over Apia must have been excited to metastable states which decayed with appreciable life-times.

The demonstration of the possibility of producing aurora artificially at once suggests the great interest that would be attached to studying the effects of any high-altitude nuclear explosions in the auroral belt, or elsewhere at still higher altitudes. Such an experiment would represent the injection of particles into the region of high particle-density recently detected by Earth satellite observations[2], and would enable one to study the storage and propagation of charged particles in this region.

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Rate of Accumulation of Nickel in Atlantic Equatorial Deep-Sea Sediments and its Bearing on Possible Extra-Terrestrial Sources

IN a recent communication, Pettersson[1] estimated the rate of accumulation of nickel on the Earth from extra-terrestrial sources on the basis of the nickel-bearing particles caught on filters located on the summits of two Hawaiian volcanoes. His value for the rate of accumulation of extra-terrestrial nickel is $6 \cdot 5 \times 10^{11}$ gm./yr. for the Earth as a whole. If the rate of accumulation is reasonably constant over the Earth's surface, then this figure corresponds to 33×10^{-6} gm. nickel/cm.^{2} of the Earth's surface/1,000 yr.

I have recently determined the rates of accumulation of nickel and other elements in a calcareous eupelagic Atlantic equatorial core (Lamont *A* 180–76), using emission spectrography and time estimates based on radiocarbon dates made on this and neighbouring cores.

In core *A* 180–76 there are three major climatic events recorded. The estimates of the duration of each climatic zone are from the paper by Broecker, Turekian and Heezen[2]. These estimates, together with the description of each zone and the calculated rates of accumulation of nickel, are given in Table 1.

Table 1

Zone	Interval (cm.)	Climate, description and duration	Average nickel content (p.p.m.)	Rate of accumulation of nickel (10^{-6} gm./cm.^{2}/1,000 yr.)
A	0–25	The most recent warm period commencing 11,000 yr. ago	13	22
B	30–260	The last major cold period (including an interstadial period) lasting about 60,000 yr.	17	49
C	265–410	The immediately preceding major warm period lasting about 80,000 yr.	13	18

The average of the rates of nickel accumulation for zones *B* and *C*, which are of about equal duration, is 33 × 10^{-6} gm./cm.^{2}/1,000 yr., comparable to Pettersson's value for extra-terrestrial accumulation. However, this must not be construed to be a confirmation of the extra-terrestrial origin of the nickel on the sea floor. There must be a significant nickel contribution from terrestrial sources to the deep-sea since the rates of accumulation of other components, such as copper and lead, are high. If nickel follows the same pattern of supply to the sea as these elements, then a major part, if not all, of this nickel accumulated may be due to terrestrial supply. In addition, the rate of accumulation of nickel, as well as several other elements and the clay fraction, varies as a function of climate, again suggesting terrestrial control of supply. Of course, this may be a matter of redistribution in the sea rather than change in total supply. This can only be confirmed by more extensive regional determinations of accumulation-rates of deep-sea sediment components in the Atlantic.

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Thermogravimetric Investigations of Peat

THE differential thermal characteristics of peat, recently reported by Mitchell[1], show an interesting correlation with results obtained in thermogravimetric studies carried out in these laboratories.

The apparatus used was a 'Stanton' thermobalance with provision for controlled atmosphere. Peat from three different sources, previously dried to approximately 10 per cent water-content for use as fuel in our experimental gas turbine, was ground and passed through a 150-mesh sieve. A 1 gm. sample was placed in a platinum crucible in the thermobalance furnace and a stream of nitrogen passed through the furnace at a velocity of 40 l./hr. Continuous recording of the weight of the sample was carried out while a rate of heating of 4° C./min. was maintained. Automatic arresting of the balance at 5-min. intervals recorded the time-scale on the weight curve. Differential curves were prepared by plotting the rate of loss of weight in mgm./min. against temperature.

The three peats used in these experiments were obtained from (*a*) Gardrum moss near Falkirk, Scotland, (*b*) Lullymore, Co. Kildare, Eire, (*c*) Altnabraec, Caithness, Scotland.

Representative differential curves obtained for these three peats are shown in Fig. 1. In all cases there is an initial evolution of water vapour in the region of 100° C., the peak occurring at a slightly higher temperature with the peats from Lullymore and Altnabraec than that from Gardrum because of the higher water-soluble contents of these peats.

Table 1. PEAKS IN DIFFERENTIAL THERMOGRAVIMETRIC CURVES OF THREE PEATS

Sample	T_1	T_2	T_3	T_2–T_1	T_3–T_2
Gardrum	350	450	525	100	75° C.
Lullymore	275	400	480	125	80° C.
Altnabraec	320	420	500	100	80° C.

T_1, First peak; T_2, second peak; T_3, third peak

Table 2. PEAKS IN COMPLETE COMBUSTION DIFFERENTIAL THERMAL CURVES (MITCHELL, *loc. cit*)

Sample	T_1	T_2	T_3	T_2–T_1	T_3–T_2
Eriophorum peat	320	420	—	100	– ° C.
Calluna peat	300	380	420	80	140° C.

T_1, First peak; T_2, second peak; T_3, third peak.

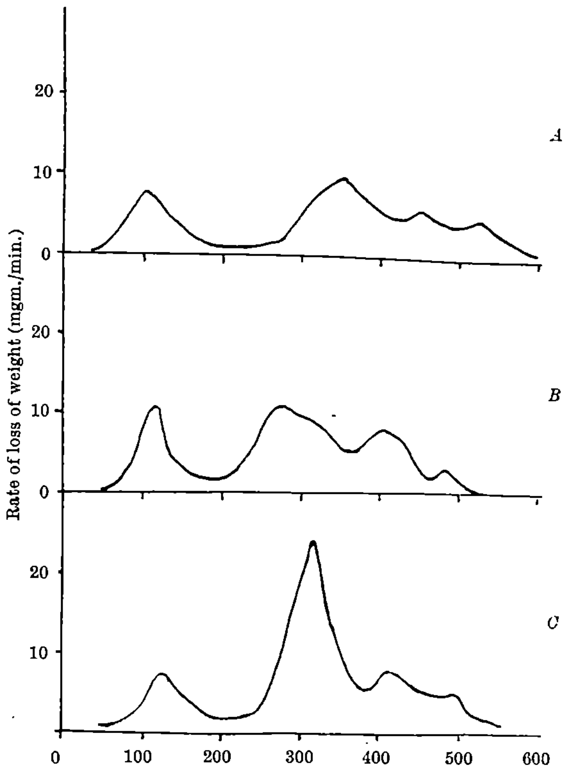

Fig. 1. Differential thermogravimetric curves of peat in nitrogen *A*, Gardrum peat; *B*, Lullymore peat; *C*, Altnabraec peat

A subsequent release of volatile matter occurs in the 250–600° C. region and exhibits a main peak followed by two smaller peaks. Although the position of the peaks varies as much as 75° C. with differing peats, their relative position in each peat is remarkably constant.

The first two peaks show a close correspondence with the two-peak system reported by Mitchell[1] in complete combustion differential thermal analysis curves (Table 2). The two main exothermic differential thermal analysis peaks must therefore result from the combustion of volatiles released at about 300° C. and 400° C. as shown by the thermogravimetric studies.

Comparative thermogravimetric studies on peat and coal have proved to be of value in predicting the burning characteristics of these fuels, and in particular in determining the degree of pre-heating necessary to release volatiles and initiate combustion.

This report is related to work done through the agency of Messrs. Ruston and Hornsby, Ltd., on behalf of the Ministry of Power, with whose permission it is now published.

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Tetrahedral Co-ordination of Nickel(II)

In a recent communication[1], Katzin has interpreted the appearance of blue colour in paramagnetic nickel(II) compounds as indicative of tetrahedral co-ordination. We have recently completed the determination of the crystal structure of $Ni(en)_2(NCS)_2$ (Brown, B. W., and Lingafelter, E. C., unpublished work). This compound is blue and paramagnetic, but the co-ordination of the nickel ion is transoctahedral, with Ni—N distances of 2·10 A. to the ethylenediamine and 2·15 A. to the *iso*thiocyanate. We are also investigating the crystal structure of $Ni(en)(H_2O)_4(NO_3)_2$, another blue paramagnetic compound. Although the study is still in the early stages and all atoms have not been located, the presence of a co-ordination octahedron about the nickel atom is already clear.

Thus these two compounds show that the blue colour cannot be taken as an indication of tetrahedral co-ordination of nickel(II).

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A Method for improving the Solute Selectivity of Osmotic Membranes

An examination of the results obtained with a pair of 'Ultracella' filters (fein)—manufactured by the Membranfiltergesellschaft, Göttingen—which had been used for several months in benzene at 30° C. to determine the number-average molecular weights ($\overline{M}_n$) of polymer samples, showed that during this time the membranes had become markedly less permeable to solvent. A similar observation has been made by Philipp and Bjork[1] with a gel 'Cellophane' membrane, and they attributed the phenomenon to gradual ageing of the membranes. However, with the 'Ultracella' filters (fein) closer examination of the results indicated that the change in permeability had occurred in two distinct stages both of which could be associated with attempts to measure the $\overline{M}_n$ of a sample of poly(diallyl phthalate). Experiments were therefore carried out with three other pairs of 'Ultracella' filters (fein) in order to investigate this phenomenon further.

The membranes were assembled in standard Zimm–Myerson type osmometers and before and after treatment with solutions of poly(diallyl phthalate) were characterized by (*a*) the solvent permeability, measured by the rate of fall of the meniscus in the measuring capillary under a head of 10 cm. of benzene, and (*b*) the solute selectivity, measured by the maximum osmotic head developed with a 1 per cent (w/w) benzene solution of a commercial polystyrene which has a very wide distribution of molecular weights[2].

The results in Table 1 show that in each case after treatment with poly(diallyl phthalate) the membranes became less permeable and more selective (that is, gave higher osmotic heads). Furthermore, these experiments show that the magnitudes of these effects (*a*) increased with poly(diallyl phthalate) concentration (membranes UCF/F 457/*A*1 and UCF/F 1256/4) up to a maximum concentration of about 1·5 per cent (w/v) (membranes UCF/F 1256/5), (*b*) after 16 hr. were independent of the time the membranes were in contact with the poly(diallyl phthalate) solution (membranes UCF/F 1256/4), (*c*) in the molecular weight-range 13,000–22,000 were

Table 1. Measurements in Benzene at 30° C.; 'Ultracella' Filters (Fein) (UCF/F)

Treatment				Permeability		Selectivity	
Poly(diallyl phthalate) solution			Time left in osmometer (hr.)	Fall from 10 cm. head of benzene		Equilibrium osmotic pressure with 1 per cent (w/w) commercial polystyrene	
Sample	$\overline{M}_n$	Concentration (per cent) (w/v)		5 min. (cm.)	30 min. (cm.)	Pressure (cm.)	Time (hr.)
UCF/F 457/*A*1							
—	—	—	—	1·31	5·85	3·35	< 16
10·1	13,000	0·1	16	0·74	3·86	4·93	6
10·1	13,000	1·5	16	0·31	1·77	6·01	6
UCF/F 1256/4							
—	—	—	—	1·25	5·04	4·43	4
BSI	22,000	0·1	16	0·92	4·03	4·65	4½
BSI	22,000	0·1	64	0·68	3·35	4·97	< 18
BSI	22,000	1·5	16	0·33	1·91	5·94	< 21½
UCF/F 1256/5							
—	—	—	—	1·58	6·27	3·93	3
BSI	22,000	1·5	64	0·46	2·56	5·83	< 22½
10·1	13,000	10	16	0·51	2·62	5·72	8

Table 2. Measurements in Benzene at 30° C.; 'Ultrafein' Filters (UFF)

Treatment				Permeability		Selectivity	
Poly(diallyl phthalate) solution			Time left in osmometer (hr.)	Fall from 10 cm. head of benzene		Equilibrium osmotic pressure with 1 per cent (w/w) commercial polystyrene	
Sample	$\overline{M}_n$	Concentration (per cent) (w/v)		5 min. (cm.)	30 min. (cm.)	Pressure (cm.)	Time (hr.)
'Ultrafein' filter (gross) (UFF/G 1157/1)							
—	—	—	—	2·96	—	5·83	2½
BSI	22,000	1·5	66	0·74	—	7·99	~20
'Ultrafein' filter (fein) (UFF/F 457/2)							
—	—	—	—	1·20	4·89	4·94	22
BSI	22,000	1·5	16	0·99	4·30	5·72	21
'Ultrafein' filter (allerfeinst) (UFF/AF 457/*A*3)							
—	—	—	—	0·045	0·296	7·30	168
2*H*	25,400	0·4	352	0·050	0·305	8·31	166

independent of the sample of poly(diallyl phthalate) used (membranes UCF/F 457/*A*1 and UCF/F 1256/4). This effect was also found with other types of membrane, for example, with all grades of 'Ultrafein' filters (UFF), in particular with the most porous grade, namely, 'gross', *G* (see Table 2).

Meyerhoff[3] has reported a similar phenomenon with some 'Ultracella' filters (feinst) which had been allowed to become saturated with a 0·5 per cent toluene solution of an oligostyrene (that is, a polystyrene of very low molecular weight, $\overline{M}_n = 1{,}200$). He attributed the effect to irreversible adsorption of the oligostyrene by the membrane material, an explanation similar to that suggested by Ferry[4] to account for the action of capillary-active substances in ultrafiltration techniques. A similar hypothesis would explain the results recorded here. However, in this case the adsorption of the poly(diallyl phthalate) may not be completely irreversible for in some cases a gradual increase in permeability has been observed during subsequent experiments.

The 10·1 sample of poly(diallyl phthalate) was obtained from W. Simpson of Metropolitan-Vickers Electrical Co., Ltd., and the samples *BSI* and *2H* were prepared by B. Selton of this Laboratory. I wish to thank Miss S. A. Monksfield and Miss H. M. Sankey for assistance with the experimental work. This work forms part of the research programme of the National Chemical Laboratory and is published by permission of the Director.

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Detection of Certain Brominated Long-Chain Fatty Acid Esters by Gas Liquid Chromatography

EVIDENCE has recently been presented which demonstrated the effects of alteration of the chemical composition of the stationary liquid upon the resolution of the methyl esters of long-chain saturated and unsaturated fatty acids by gas-liquid chromatography[1-4]. When the adipate, glutarate and succinate polyesters of diethylene glycol were used as liquid phases, the more polar unsaturated fatty acid esters were retained on the column to a greater degree than the saturated members of similar carbon chain-length. The number and position of the unsaturated linkages appeared to be the dominating factors in determining the affinity of the component vapour for the stationary liquid. The greater the degree of unsaturation beyond the 9,10 position in the fatty acid ester molecule, the slower was the movement of the substance down the column. This effect appeared to be modified somewhat by the occurrence of a double bond closer to the carboxyl group, that is, before the 9,10 position, which tended to hasten the emergence of the compound from the column. Although the polyesters were much more efficient as stationary liquids than the comparatively non-polar 'Apiezon' and silicone greases[5,6] for achieving separations of saturated and unsaturated fatty acid esters, when samples of fatty acid esters of unknown composition were analysed by gas-liquid chromatography, the possible presence of esters of branched-chain acids, odd-numbered acids, and unusual mono-, di- and poly-unsaturated acids still made difficult the positive identification of the individual components on the basis of comparative retention times and volumes.

Bromination of a mixture which has been previously analysed chromatographically and then re-running the brominated sample has been a common technique for determining the presence of compounds containing double bonds. Bromine adds to the double bonds to form a dibromide, tetrabromide, hexabromide, etc., depending upon the degree of unsaturation. In the early methods which employed columns containing 'Celite 545' coated with 'Apiezon' at 200° C. for the determination of fatty acids by gas-liquid chromatography, detection of brominated components was not noted[6]. Under these conditions, the disappearance of certain compounds following bromination and rechromatography was indicative of those substances in the original mixture that contained unsaturated linkages. The chain-length and number of double bonds were estimated according to the comparative retention times and volumes. The position of the double bonds was then determined by additional oxidative procedures[7].

A study was undertaken in this laboratory in an effort to detect by the gas-liquid chromatographic technique the presence of brominated fatty acid esters on columns containing highly polar polyesters as liquid phases. A mixture containing 34 per cent of methyl stearate and 66 per cent methyl oleate was resolved on a chromatographic column 8 ft. long containing 60–80 mesh 'Celite 545' coated with 10 per cent glutarate polyester of diethylene glycol at 205° C. An ionization chamber was used as a detection device. The rate of flow of argon was 60 ml. per min. The stearate and oleate bands had corrected retention volumes of 570 ml. and 645 ml. respectively. Aliquots of the same mixture were brominated by several procedures and then reapplied to the same column. A chromatogram of the brominated mixture revealed the presence of three peaks in addition to that of the unchanged stearate (Fig. 1). It was unlikely that any of the peaks represented unbrominated oleate since their retention times were longer than that of oleate. This was further verified by rebromination of the mixture which when re-chromatographed did not alter the appearance of the chromatogram.

The retention volumes and percentage composition of the three new components are presented in Table 1. By altering the operating parameters, the largest peak (No. 3) was found to contain another component from which it was partially resolved.

It should be noted that other mono-unsaturated acid esters yielded volatile brominated products which could be detected under the operating conditions already defined of the gas chromatographic technique. However, when methyl linoleate was brominated and the products analysed, distinct peaks were absent, although after 13 min. a shift in the

Table 1. RETENTION VOLUMES AND PERCENTAGE COMPOSITION OF THE BROMINATED MIXTURE

Component No.	Corrected retention volumes	Percentage
2*	570 ml.	34
3	675 ,,	39
4	1,050 ,,	12
5	1,260 ,,	15

* Methyl stearate, unchanged by bromination.

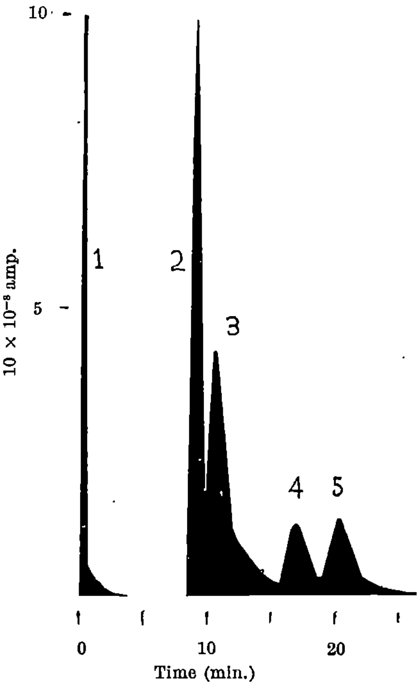

Fig. 1. Gas-liquid chromatographic analysis of a brominated mixture of methyl stearate (34 per cent) and methyl oleate (66 per cent), using an 8-ft. column containing 60–80 mesh 'Celite 545' coated with 10 per cent polydiethylene glycol glutarate at 205° C. Argon flow-rate, 60 ml./min. An ionization chamber was used as a detection device. 1, Solvent peak; 2, stearate; 3, 4 and 5, brominated products

base line was noted which continued for another 15 min. (The retention time of methyl linoleate under these conditions was 13 min.)

The exact chemical nature of the components found in the brominated mixtures is obscure. Although the materials appeared to be saturated when applied to the column, it is conceivable that dehydrobromination to yield mono-bromo-mono-unsaturated or doubly unsaturated compounds could occur during passage down the column. It is significant that even though side reactions may occur during or after bromination these nevertheless appear to be quantitatively reproducible. No differences were noted when (*a*) the bromination procedure was carried out by using pyridine sulphate dibromide in acetic acid or free bromine (1 per cent) in ether, and (*b*) the excess bromine was destroyed before removing the solvent or evaporated off along with the solvent.

The major brominated peak (Fig. 1, No. 3) is probably methyl 9,10-dibromostearate. The rapid emergence of this compound from columns containing polyesters as liquid phases is in sharp contrast to the behaviour of this substance when the 'Apiezon' greases were employed as stationary liquids. In these latter circumstances, detection of this material was noted only when the columns were operated[8] at 275° C. It cannot be determined at the present time whether or not the double peak (Fig. 1, No. 3) represents *d*- and *l*-dibromostearate, the anticipated product of bromination of a *cis* double bond.

When methyl elaidate was brominated, a similar pattern with much broader peaks was seen. Splitting of the major peak was not achieved, but this was no reason to believe it was homogeneous even though the *meso* dibromide is the expected product.

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Alleged Susceptibility of Sulphydryl Enzymes to Ionizing Radiation

SINCE the work of Barron *et al.*[1–3] it has been generally assumed that sulphydryl enzymes, in contrast to enzymes not requiring free SH-groups for their activity, are exceptionally susceptible to the indirect action of ionizing radiation. This view, which has profoundly influenced radiobiological thinking during the past decade, is not supported by recent experiments in this laboratory. In the present communication results are presented to show that the sulphydryl enzymes muscle glyceraldehyde-3-phosphate dehydrogenase and yeast alcohol dehydrogenase are inactivated by X-rays with about the same ionic yield as various non-sulphydryl enzymes.

Crystalline muscle glyceraldehyde-3-phosphate dehydrogenase (specific activity $3 \cdot 8 \times 10^5$ as defined by Velick[4]) and crystalline yeast alcohol dehydrogenase (specific activity $1 \cdot 8 \times 10^5$ units per mgm. protein[5]) were prepared[4,5]. In both cases the enzyme activity was determined spectrophotometrically under conditions of substrate and coenzyme concentrations which are optimal for measuring the activity of the apoenzyme[3,4].

It appears from Table 1 that when irradiated in dilute aqueous solutions equilibrated with air, both enzymes were inactivated by X-rays with ionic yields of about 0·02. These yields fall in the same range as those previously reported for a number of non-sulphydryl enzymes[1,2,6–8], providing evidence that glyceraldehyde-3-phosphate dehydrogenase and alcohol dehydrogenase are not particularly sensitive to the indirect action of ionizing radiation. The results stand in striking contrast to the reports by Barron *et al.*[1–3] that these enzymes are inactivated with ionic yields of about 1. Furthermore, the claim that glyceraldehyde-3-phosphate dehydrogenase can be partly reactivated by addition of reduced glutathione after irradiation[1] could not be confirmed.

The results here reported do not constitute evidence against the view that protein SH-groups are highly susceptible to ionizing radiation. Since the most active alcohol dehydrogenase preparations contain up to 36 titratable SH-groups[9], the present results with alcohol dehydrogenase are consistent with the assumption that in solution each accessible SH-group is inactivated with an ionic yield of about 1. A linear relationship is known to exist between the number of free SH-groups (in the interval 4·5–36) and the enzyme activity[9]. The present finding that aged alcohol dehydrogenase preparations with lower specific activities are inactivated with unchanged ionic yield (Table 1) suggests that the disappearance

Table 1. INACTIVATION OF GLYCERALDEHYDE-3-PHOSPHATE DEHYDROGENASE (GAPDH) AND ALCOHOL DEHYDROGENASE (ADH) BY X-RAYS

Irradiation conditions: 70 μgm. glyceraldehyde-3-phosphate dehydrogenase per ml. 0·07 *M* phosphate buffer, *p*H 7·4 (5×10^{-7} *M*); 45 μgm. alcohol dehydrogenase per ml. 0·01 *M* phosphate buffer, *p*H 7·4 (3×10^{-7} *M*). The enzyme solutions, equilibrated with air, were irradiated at 3° C. Irradiation factors: 4 m.amp., 200 keV., 0·5 mm. copper filter

Enzyme	Specific activity	Radiation dose (r.)	Remaining enzyme activity (per cent)	Ionic yield*
GAPDH	$3{\cdot}8 \times 10^5$	0 585 1,170 2,340	100 92 84 69	— 0·023 0·023 0·022
ADH	$1{\cdot}8 \times 10^5$	0 585 1,170 2,340	100 89 76 54	— 0·020 0·020 0·020
ADH	$7{\cdot}6 \times 10^4$	0 2,340	100 54	— 0·020
ADH	$4{\cdot}56 \times 10^4$	0 2,340	100 53	— 0·020

* 1 r. is assumed to give 3×10^{-9} *M* ion-pairs in solution

of free SH-groups accompanying the fall in activity[9] does not influence the ability to capture radicals of the sulphur atoms in question. Probably the ageing involves the conversion of SH- to SS-groups, which are likewise known to be highly susceptible to the indirect effect of ionizing radiation.

A complete report of this work will appear elsewhere.

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Phylogenetic Distribution of Acid Phosphatase inhibited by (+)-Tartrate

AN interesting stereo-specific inhibition by (+)-tartaric acid of certain acid phosphatases of human origin has been reported by Abul-Fadl and King[1]. We have had occasion in our work to note, as certainly many others must have, that inhibition by (+)-tartrate is a property which extends to other mammalian phosphatases. On the other hand, we have observed that none of a number of acid phosphatases present in crude extracts obtained from higher plants was preferentially inhibited by this substance. On further investigation of acid phosphatases of both plant and animal sources, we have consistently found the property of specific inhibition by (+)-tartrate to be associated with those organisms which are universally accepted as members of the animal kingdom, whereas those which are customarily regarded as plants invariably did not possess such an enzyme. In view of this sharp division, it became of interest to examine the protists, and these results are shown in Table 1, along with those obtained with *bona fide* 'plants' and 'animals'. Only a few examples of the many which are available for the higher plants and animals are given. We have listed all the lower forms of plants and animals and of the protists which we have been able to test (except a number of bacteria, all of which were negative).

Table 1. INHIBITION OF BIOLOGICAL ORGANISMS BY (+)-TARTRATE. The reaction mixtures consisted of 2 ml. of *p*-nitrophenyl phosphate (0·015 *M* in 0·1125 *M* acetate buffer, *p*H 5·0), 0·5 ml. of inhibitor, and 0·5–2·0 ml. of enzyme in a final volume of 4·5 ml. The tests were carried out with the aqueous extracts of the various organisms, essentially as described previously (ref. 2)

Source	Per cent inhibition by tartrate	
	(+)-isomer 0·02 *M*	(−)-isomer 0·02 *M*
Monezia expansa	51	10
Ascaris lumbricoides	37	0
Snail (*Helisoma* sp.)	45	0
Crayfish (*Orcconectes* sp.)	67	0
Cockroach (*Periplaneta americana* (L.))	48	0
Chicken liver	32	0
Rat liver	63	0
Human prostate	93	0
Physcomitrium turbinatum	0	0
Ginkgo biloba, seed	0	0
Brassica oleracea	0	0
Tetrahymena pyriformis	33	0
Euglena gracilis	58	0
Astasia longa	33	0
Chlamydomonas pseudococcum	0	0
Polytoma obtusum	19	11
Physarum polycephalum	73	21 (0·04 *M*)
Blastocladiella emersonii	35	19
Rhizopus nigricans	0	0
Mucor sp.	0	0
Phytophthora parasitica	62	18
Pythium ultimum	46	19
Neurospora crassa	51	0
Penicillium sclerotiorum	30	0
Aspergillus oryzae (taka-diastase)	36	0
Ceratostomella fimbriata	65	0
Stemphillium radicinum	39	0
Glomerella sp.	418	0
Agaricus campestris	62	0
Puccinia recondita (uredospores)	39	0
Saccharomyces cerevisae	0	0
Sporobolomyces sp.	0	0
Leuconostoc mesenteroides	0	0
Bacillus coagulans	0	0
Thermoactinomyces sp.	20	20
Streptomyces griseus	0	0
Actinomycetes sp.	0	0

Several points of interest may be noted. In no case have we encountered an exception to the rule that 'unequivocal' plants lack, and animals possess, phosphatases inhibitable by (+)-tartrate. The euglenids are like the animals; the superficially similar chlamydomonads are like the plants. *Tetrahymena pyriformis*, a true protozoan, is, by this criterion, animal-like. All the bacteria tested, including the morphologically complex Actinomycetes, are plant-like. So also are *Saccharomyces cerevisae*, an ascomycetous yeast, and *Sporobolomyces*, which forms ballistospores. Among the Phycomycetes, it was found that *Rhizopus* and *Mucor* species do not possess the inhibitable phosphatases, whereas *Phytophthora*, *Pythium* and *Blastocladiella* do. The crude acid phosphatase of the slime mould, *Physarium polycephalum*, was very sensitive to (+)-tartrate. All the species of Ascomycetes and Basidiomycetes tested contained the inhibitable enzyme.

We do not wish to emphasize unduly the 'animalness' of the lower organisms; we realize that the dichotomy of the plant and animal kingdom may be no more than a man-made division. Neither do we wish to presume that there are only two main phylogenetic trunks. Nevertheless, we do direct attention to the possible utility of inhibition by (+)-tartrate as a taxonomic device, even if it may not necessarily hold any profound implications for the moot problem (to some biologists) of how one tells the plants from the animals.

A word of caution needs be expressed. In all cases only crude extracts were tested. Not all animal phosphatases are inhibited by (+)-tartrate, and it should be noted that a concentration of 0·02 *M* (+)-tartrate, which is sufficient to cause a 93 per cent inhibition of the prostatic acid phosphatase, a source of acid phosphatase fairly homogeneous with respect to a single phophomonoesterase, did not cause a similar degree of inhibition with other animal phosphatases. With the animal preparations shown, it is possible that these do contain some non-inhibitable phosphatases as well. It is not impossible that extracts which we report as non-inhibitable do contain quantities of phosphatases inhibitable by (+)-tartrate too small to be significant in our assay. The possibility that the inhibition was due to non-specific ionic effects or to sequestering of essential cations was controlled by the use of (−)-tartaric acid.

We are greatly indebted to our many biologist colleagues at the University of California in Los Angeles, the University of Michigan, Michigan State University, and Purdue University for many of the organisms used in this work.

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Occurrence of α-Picoline in Plants

WILKINSON[1] has recently directed attention to the occurrence of α-picoline in the leaves of *Rumex obtusifolians*, which is believed to be the first record of the presence of this substance in plant material.

It is perhaps of interest to refer to some earlier investigations on the occurrence of a fluorescent alkaloid in rye-grass (*Lolium perenne* L.), in which was also recorded the isolation of other less-complex nitrogenous substances including a picoline-like compound[2,3]. This compound was not completely identified; but its absorption spectrum and empirical formula were indistinguishable from those of a picoline. However, close comparisons between the melting points and mixed melting points of the picrates and mercurichlorides with those of the α, β and γ picolines failed to identify the base, as did comparisons with the melting points of the fully hydrogenated derivatives. Moreover, no acidic products were obtained during oxidation under conditions which resulted in the formation from α-, β- and γ-picolines of the corresponding acids.

We have not had a further opportunity to investigate the nature of this base, but we are now prompted to recall our findings in the hope that these earlier results will be clarified by other workers.

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Fermentation of Glucose by *Chlorella vulgaris*

IT has been shown recently that the chief products of glucose fermentation by *Chlorella vulgaris* (Pearsall's strain) are acetic acid, lactic acid, hydrogen and a little carbon dioxide[1]. It was of interest to study the fermentation of glucose labelled with carbon-14 in particular carbon atoms since, from a determination of the distribution of carbon-14 in the molecules of the products, something can be learnt of the fermentation pathway.

2 μc. and 1·5 μmoles glucose were supplied to 40 mgm. dry weight *Chlorella* suspended in 2 ml. 0·02 *M* phosphate, *p*H 7·0, in Warburg flasks which were filled with oxygen-free nitrogen; the flasks were shaken at 25° C. in darkness. The radioactive glucose was supplied by the Radiochemical Centre, Amersham, and was labelled in either the 1, 2 or 6 carbon atoms or was uniformly labelled. Carbon dioxide was collected in sodium hydroxide in the centre-wells of the Warburg flasks. When fermentation had ceased, the centre-well solutions were withdrawn and the carbonate precipitated and counted as barium carbonate after the addition of 1·5 mmoles sodium carbonate as carrier. The cell suspensions were removed, 1·5 mmoles acetic acid and 1·5 mmoles lactic acid added to each and the cells killed by heating to 100° C. The cells were extracted with hot water and the extracts run through columns of 'Zeokarb 215' to remove amino-acids. Acetic acid was then removed by steam distillation. Lactic acid in the residue was obtained either by ether extraction or by separation on a silica-gel column[2]. The acetic and lactic acids were then degraded[3] and their carbon atoms recovered as carbon dioxide. All counts were made on barium carbonate samples of infinite thickness. The distribution of carbon-14 is shown in Table 1.

Table 1. THE DISTRIBUTION OF CARBON-14 IN THE ACETIC ACID AND LACTIC ACID PRODUCED DURING THE FERMENTATION OF 1·5 μMOLES AND 2 μC. OF GLUCOSE-1-^{14}C, GLUCOSE-2-^{14}C OR GLUCOSE-6-^{14}C BY *Chlorella vulgaris*

The figures show the percentage of the total radioactivity contributed by each carbon atom in the molecules of the products. The last column shows the radioactivity in the carbon dioxide produced by the fermentation

Glucose supplied	Acetic acid CH_3—COOH		Lactic acid CH_3—CHOH—COOH			C.p.m. in carbon dioxide
Glucose-1-^{14}C	98·5	1·5	81·0	0·3	18·7	589
Glucose-2-^{14}C	1·7	98·3	0·7	85·9	13·4	363
Glucose-6-^{14}C	98·2	1·8	87·0	0·1	12·9	335
Uniformly labelled	—	—	—	—	—	1,071

The results show that the 1- and 6-carbon atoms of glucose are converted to the CH_3- carbon of lactic and acetic acids while the 2-carbon atom is converted to the —CHOH— carbon atom of lactic acid and to the —COOH carbon of acetic acid. This is the labelling pattern which would result if glucose were split by the Embden–Meyerhof–Parnas glycolysis reactions into two C_3 fragments which were either converted to lactic acid or decarboxylated to a precursor of acetic acid. In agreement with this view is the fact that most of the carbon dioxide produced during the fermentation appears to arise from the 3- and 4-carbons of glucose. The yield of carbon-14 dioxide from uniformly labelled glucose is much greater than that from the 1, 2 or 6 labelled sugar. If one assumes that the contribution of the 5-carbon of glucose to the carbon dioxide production is equal to that of the

2-carbon, the relative contributions of the glucose carbons to the carbon dioxide production can be calculated as (per cent): C_1, 9·2; C_2, 5·7; C_3 and C_4 together, 74·2; C_5, 5·7; C_6, 5·2. Nevertheless, all the glucose carbons contribute to the carbon dioxide production and the 1-carbon contributes more than the 6-carbon. Consequently, reactions other than the Embden–Meyerhof–Parnas glycolysis ones must be involved to some extent.

The labelling of the carboxyl group of lactic acid is noteworthy. It is probably a result of carbon dioxide fixation, which is known to occur during glucose fermentation by *Chlorella*[1].

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Isolation of Oxo-Steroids under Neutral Conditions

Girard's reagent *T* (trimethylammonium hydrazide chloride)[1] is extensively used for the separation of oxo-steroids from other steroids and particularly for purification of 17-oxo-steroids in extracts of acid- or enzyme-hydrolysed urine[2]. The method employed usually involves dissolving the material and Girard reagent in glacial acetic acid, and either heating the mixture for periods of up to 1 hr. or allowing it to stand overnight at room temperature. During this procedure destruction of labile steroids and some acetylation of hydroxy-steroids tend to occur (ref. 3 and unpublished observations).

Before extraction of non-ketonic material from the water-soluble Girard complex the acetic acid is nine-tenths neutralized by addition of strong alkali. The heat evolved, which may be deleterious to some steroids, is counteracted by carrying out the neutralization under ice-cold conditions. After extraction of the non-ketonic material the Girard complex is hydrolysed by taking the solution to *p*H 1 and allowing it to stand for 2–48 hr. Under these conditions destruction of labile steroids may occur.

Recently, Teitelbaum[4] has described an elegant modification of the method for application to labile aldehydes and ketones such as citral, benzaldehyde, etc., which are extensively destroyed by the old method. The new method involves forming the Girard complex in ethanolic solution in the presence of cation exchange resin ('Amberlite *IRC*50'), and then splitting the complex by adding excess aqueous formaldehyde. Thus many of the disadvantages of the old method have been avoided, and also the new method is simpler and less time-consuming.

The applicability of the new method to oxo-steroids has therefore been investigated. In these exploratory experiments the steroids used were progesterone (I) and 21-hydroxy-5β-pregnane-3 : 20-dione (II) (pregnanediolone). The steroid (10 mgm.) was dissolved in 1 ml. ethanol and 20 mgm. Girard reagent *T* and 5 mgm. 'Amberlite *IRC*50' were added. The mixture was heated under reflux for 1 hr., and after addition of 10 ml. water was extracted 3 × with 10 ml. solvent (ether for I ethyl acetate for II). The amount of steroid appearing in this non-ketonic fraction was then determined. After addition of 2 ml. of 40 per cent formalin, the aqueous solution of the Girard complex was allowed to stand overnight. Extraction with solvent then yielded the ketonic fraction. For comparison 10 mgm. steroid were also treated by the old method[2].

The results presented in Table 1 show that the new method is more effective than the old.

Table 1

Steroid	Percentage recovery from: (*a*) Non-ketonic fraction	Percentage recovery from: (*b*) Ketonic fraction
Progesterone:		
Old method	0·5–1·5	82–86
New method	0·4–1·0	92–96
21-Hydroxy-5β-pregnane-3 : 20-dione:		
Old method	< 1	80–82*
New method	< 1	90–95

* Approximately 10 per cent of product was acetylated at C-21.

Further experiments were carried out with progesterone to determine the rate of formation of the Girard complex at room-temperature using the new method. The results are shown in Table 2. It can be seen that complex formation is fairly rapid at room temperature, and is virtually complete in 7 hr.

Table 2

Time (hr.)	0·25	0·5	1	2	3	7	24
Progesterone in non-ketonic fraction (per cent)	84	76	55	15	10	3	1

The rate of splitting of the Girard reagent – progesterone complex by formaldehyde was also investigated, and the results are shown in Table 3.

Table 3

Time (hr.)	0·1	1	7	17	24
Progesterone in ketonic fraction (per cent)	40	76	95	98	98

Thus it is apparent that this new method of using the Girard reagent is applicable to steroids, and in view of the mild conditions employed it is recommended for use, particularly in work with labile steroids.

I wish to acknowledge gifts of steroids from Drs. C. L. Hewett (Organon) and G. D. Laubach (Pfizer).

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Electroencephalograph Correlates of Ammonium Carbonate Intoxication in the Rat

In the literature[1,2] relating to ammonia intoxication in man and animals, the basic assumption has been that ammonia exerts a primary chemical action on brain cells. However, of the two papers in the animal experimental group on the effect of ammonia on the functioning of the central nervous system using electroencephalography, Marsan *et al.*[3] interpreted the transiently decreased electrical activity observed in the dog's brain as a direct consequence of general cellular anoxia due to an embarrassed cardiac output; and Torda[4] believed her results indicated an increase in cerebral activity because of the paroxysmal slow waves following the intraperitoneal injection of ammonium chloride. We have demonstrated that under proper conditions of administration of ammonium salt, a primary cortical neuronal response may be achieved, as evidenced by a decreased electric output.

11 per cent (w/v) of ammonium carbonate (reagent grade) in glass-distilled water was administered intravenously in divided doses of 27–220 mgm./kgm. of body-weight to segregated female Sprague–Dawley rats weighing 239–300 gm. A total of 63 experiments was performed. All electrode implantations, vessel and tracheal cannulations were performed under ether anæsthesia. Some animals were later immobilized by tubocurarine intravenously administered. In these cases, the curarizing material was injected slowly and titrated to the level of either minimal electroencephalographic change, or to the cessation of respirations, whichever appeared first. Oxygen was administered by an intermittent positive pressure system. The electroencephalograph derivations were obtained by means of small brass wood-screws placed in the homologous bilateral frontal and occipital regions of the skull. Variations in blood pressure were transduced with a Statham type 23 *A* strain-gauge, suitably connected to the abdominal aorta. The electrocardiograph was derived from clips attached to the skin behind the forepaws. All electrical measurements were made with Offner 141 amplifiers and dynagraph records. The ammonium carbonate was administered intravenously over an interval of 10–20 sec., in doses of 27–55 mgm./kgm. body-weight.

Section 4 of Fig. 1 is representative of the control electroencephalograph, electrocardiograph and blood pressure. In section 5 with the administration of ammonium carbonate in two successive doses of 55 mgm./kgm. each, a decrease in amplitude of the electroencephalograph was observed within 20 sec.; no substantial alteration in the heart function was recognized. Section 6 shows recovery of the brain activity to its control type. This section also shows the electrical activity at the end of the third administration of the chemical. Within 1 min. after this latter injection, section 7 again illustrates the decrease in amplitude of the output of the electroencephalograph. Array 8 shows the electroencephalograph activity 1 min. after the preceding; it is observed that the output becomes almost isoelectric; the heart function shows no evidence of impairment. Approximately 10 min. after the preceding section of waves (section 8), recovery again took place in section 9. Section 10 shows tracings, 1½ min. after the injection of only 55 mgm. of ammonium carbonate per kgm. body-weight. The isoelectric output is evident. We have accomplished such recycling repeatedly. Clinically the animals remain in a state of unresponsiveness during the interval of diminished electrical output; they can in no way be considered 'alerted'.

Ulshafer[2] showed that rats injected with ammonium carbonate had a consistent diminution in the acetylcholine-level of the brain as compared with controls. Larger doses of the chemical decreased the measured amount of acetylcholine of the brain. He suggested that the decreased brain acetylcholine resulted from the action of the ammonium ion in the conversion of glutamic acid to glutamine. We believe, therefore, that the electroencephalographic changes demonstrated are consistent with, and an expression of, a reduced acetylcholine content of the brain.

In conclusion, our material demonstrates that ammonium carbonate has a direct action on the central nervous tissue of the rat. This action is to reduce spontaneous electrical output.

The technical assistance of Donald H. Lentz and Dr. Morris H. Lampert is acknowledged.

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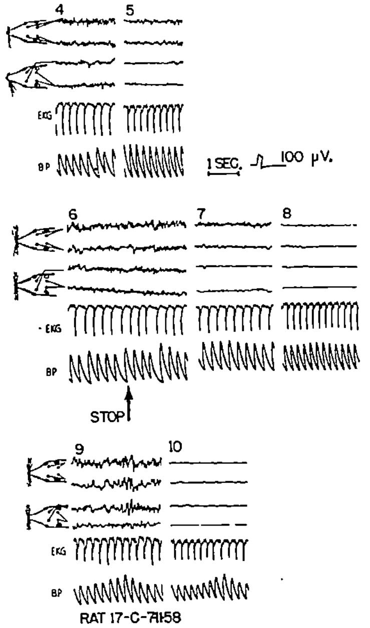

Fig. 1

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Dependence of Latent Period in Muscle on Strength of Stimulus

The so-called latent period, which includes latency relaxation, has an important bearing on theories of excitation coupling. It is surprising then that systematic studies[1,2] of this phenomenon do not mention the role of the stimulus. The reason is that, with the frog sartorius, increasing strength of stimulus above twice the threshold value apparently produces no significant effect on the latency, while below this value the effects may conceivably be dismissed as due to 'recruitment of fibres'. Even here, however, latency relaxation increases and may reach as much as 1 per cent of tetanus tension at ten times threshold field-strength.

In my experiments, to eliminate conduction-time effects, stimulation is by transverse field—an arrangement introduced by Brown and Sichel[3] in their study of single sartorius fibres. It is noteworthy that the records of these authors (their Fig. 6, p. 324) show clear evidence of decrease of latent period with increase of field, as well as increase of twitch tension.

These effects can be seen in whole muscles other than the sartorius in much more striking form. Fig. 1 shows a result obtained with a muscle similar to toad sartorius. With increasing field three effects occur in

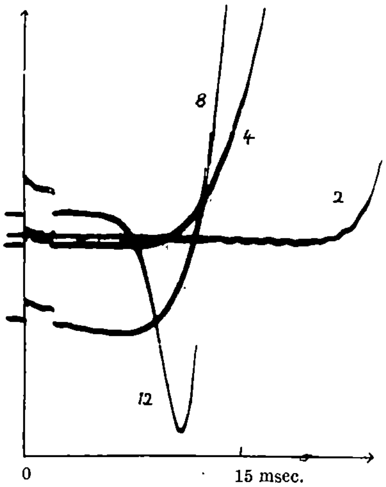

Fig. 1. Latent period in r. capitis-collique of turtle (*Chrysemys pictans*) at 0° C. Ordinate: tension. Figures refer to stimulus strength in V./cm. Duration of stimulus, 1·5 msec. (shown superimposed on tension record)

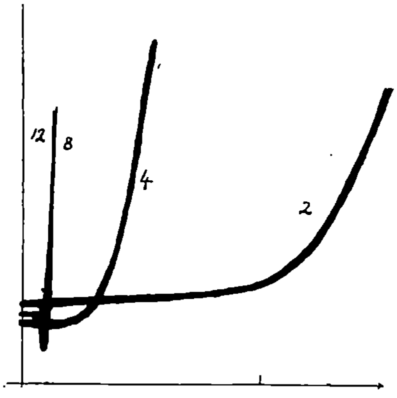

Fig. 2. Latent period in r. penis of turtle (*Pseudemys elegans*), 0° C. Duration of stimulus, 3 m.sec. Note that latency relaxation begins at 8 V./cm. while the record for 12 V./cm. is virtually superimposed on this

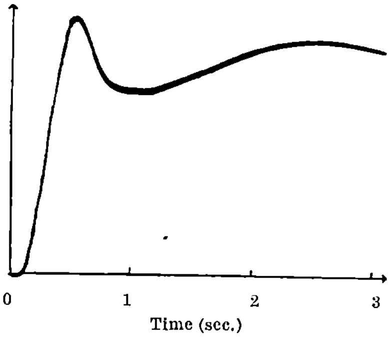

Fig. 3. Subsequent isometric development of tension for curve of Fig. 2 for 8 V./cm. Second peak corresponds to normal twitch as obtained from a propagated action potential

sequence : (1) decrease of latent period ; (2) increase of initial rate of development of tension ; (3) onset of latency relaxation.

The same is true for a slow tonic muscle (Fig. 2) where, however, effects 1 and 2 are much greater and occur simultaneously. In fact the effect 2 is so great as to show a spike of tension (Fig. 3), reminiscent of a 'quick stretch' effect[4], superimposed on the normal twitch response. By varying the duration of the stimulus one finds that the time constant for the process involved is about 1 msec.

These observations are consistent with the view that by transverse stimulation we can drive the membrane to greater amplitudes than the normal propagated action potential, thereby accelerating a process precursor to activation.

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Lysins and Agglutinins in Normal and Lymphomatous Mouse Tissue

LYSINS and agglutinins have been extracted from normal mouse tissues, and often in much higher concentration from the mammary adenocarcinomas of the female *C3H* mouse. Three methods have been used for extraction[1–4] : (*a*) extraction of minced-up tissues in saline (1 per cent sodium chloride), (*b*) 'pre-incubation' of homogenized tissue at 37° C. in saline for 12–18 hr., which results in the separation of a yellow hæmolytic fluid, and (*c*) extraction with ether, which gives an ether-soluble 'soap-like' lytic material and also a lytic material insoluble in cold ether ('lysolecithin'). These methods and their results have been reviewed by Ponder[3] in relation to a background which begins with the work of Metchnikoff in 1893. Probably only method (*a*) is of real value for demonstrating tissue lysins and inhibitors ; the other two methods are to some extent unreliable since they involve the splitting of pre-existing complexes.

Recently, Pirofsky[5] has obtained lysins and agglutinins, detected by trypsinized red cells, from the white cells of human leukæmia (7 chronic lymphatic, 4 chronic myelogenous and 2 acute leukæmias). Many, but not all, of the properties of these extracted substances are like those of extracts of mouse tissues and tumours, but the extraction media used are different (30 per cent sucrose, 11·5 per cent sodium chloride and 0·82 per cent sodium chloride), and neither the lysin nor the agglutinin was found to be soluble in alcohol or ether. They are not related to the β-hyaluronidase described by Leroy and Spurrier[6], and a non-dialysable substance in plasma inhibits their action.

This communication is concerned with the lytic and agglutinating properties of fresh homogenized lymph glands from normal and leukæmic (better termed lymphomatous) *AKR* mice. The mice are killed and the lymph nodes dissected out immediately ; in the lymphomatous mouse, the thymus may be large and infiltrated with lymphoma cells. In the normal mouse, the tissue which is homogenized is the lung. Blood is withdrawn from the heart. The nodes (normal and lymphomatous as determined later by section) are homogenized for 5 min. in a 'Vir-Tis' homogenizer moving at 35,000 rev./min., the proportion used being 200 mgm. of tissue in 1 ml. of saline. Centrifuging for a few minutes removes gross particles, and the homogenate is diluted with Michaelis's buffer at *p*H 7 in powers of 2. The red cells obtained from the heart are washed three times with saline, packed, and 0·1 ml. suspended in 10 ml. of saline. They are not trypsinized. A volume of

Table 1

Tissue	1 hr.	2 hr.	3 hr.
Normal	3, 4	2, 3, 4	2, 3, 4
Normal	0	0	0
Normal	0	0	2
Leukæmic	0	3	3, 4
Leukæmic	2, 3	2, 3, 4	2, 3, 4, 5
Leukæmic	2, 3, 4	2, 3, 4, 5	2, 3, 4, 5

0·1 ml. of the dilute red-cell suspension is added to each tube containing 0·2 ml. of diluted homogenate. The tubes are placed in a water-bath at 37° C., and are observed for lysis or agglutination for 3 hr. Controls are included.

Table 1 is self-explanatory. Lysis (complete) and agglutination are expressed in terms of the tubes in which they occur; for example, lysis 3–4 means that complete lysis occurs in tubes 3 and 4 of the series of dilution of the homogenate in powers of 2. Tubes containing higher concentrations of the homogenate, for example, tubes 1 and 2, always show agglutination, whereas tubes containing smaller concentrations of the homogenate than those which produce lysis, for example, tubes 5, 6, etc., show neither lysis nor agglutination. So far as lysis is concerned, each series of dilutions shows a zone phenomenon like that described for extracts of mouse carcinoma[4]. The lytic phenomenon is dependent on *p*H, occurring in the highest dilutions of the homogenates at a *p*H between 7 and 8.

Lytic material can be extracted by adding to 1 volume of the homogenate either 3 volumes of hot alcohol or the same amount of hot ether or of cold (2° C.) ether, shaking, filtering, evaporating the alcohol or ether to dryness under a fan at room temperature, and taking up the dry residues with Michaelis's buffer at *p*H 7. This rapid method of extraction is preferable to the longer method described by Ponder[2], particularly when only small amounts of homogenate are available. If Pirofsky is right in saying that these methods fail to extract lytic material from human leukæmic cells, there is a demonstrable difference between the lytic substances of mouse tumours, mouse leukæmia and human leukæmia. Unfortunately, the extraction methods were devised to be applied to blood and to pre-incubated tissues, including mouse tumours; the lytic material is bound to proteins, from which it may be split off by the extraction. There is no reason for thinking that this lytic material is the same as that in homogenates which have not been pre-incubated and extracted, which sometimes produce lysis in less than an hour. The concentration and nature of the latter material are still unknown, except that it too seems to be associated with inhibitors (agglutinins), and that it is found in normal as well as malignant and leukæmic tissues of the mouse, the concentration in normal tissues, however, usually being small.

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Levels of Serum Cholesterol in Obese Mice

CHOLESTEROL-levels have been the object of considerable attention lately because of their possible relation to degenerative diseases, atherosclerosis in particular. In a number of experiments hypercholesterolæmia has been produced in experimental animals by adding cholesterol to the diet and by making other dietary changes.

It may be useful to direct attention to the fact that spontaneous hypercholesterolæmia in the absence of any cholesterol feeding has been observed under three conditions in the mouse. During the past few years, this laboratory has been engaged in a study of the etiology of the various forms of obesity using the mouse as the experimental animal[1,2]. Hypercholesterolæmia was observed to be invariably present in the hereditary obese hyperglycæmic syndrome, in the obesity due to the grafting of tumours secreting adrenocorticotrophic hormone and is also seen in female yellow obese mice. By contrast, hypercholesterolæmia is not seen in goldthioglucose-hypothalamic obesity (nor, for that matter, in the hypothalamic obesity induced by the use of stereotaxic instruments). It was thought useful to compare results pertaining to serum cholesterol-levels in various forms of obesity in the mouse which have been published only in fragmentary form.

Table 1 summarizes serum cholesterol values determined by the Kendall–Abell method in four types of obese mice[3]. It is readily seen that the obese-hyperglycæmic mice and obese mice with tumours secreting adrenocorticotrophic hormone have serum cholesterol-levels about twice as high as those of their respective controls. These two types of obesity are representative of what has been called 'metabolic' obesity, namely, those types of obesities in which the hyperphagia is secondary to metabolic disorders of fat and carbohydrate metabolism. Such animals are characterized by increased lipogenesis and cholesterologenesis, even under fasting conditions[4,5]; by the retention of a high body-fat content even when the animals are reduced to the control weight

Table 1. SERUM CHOLESTEROL LEVELS IN FOUR TYPES OF EXPERIMENTAL OBESITY IN MICE

Results for the first three types of obese mice are for males and females pooled as there is no sex difference with respect to serum cholesterol levels

Types and No. of mice	Body-weight		Serum cholesterol (mgm./100 ml.)	
	Range (gm.)	Average and stand. deviation	Range (gm.)	Average and stand. deviation
Goldthioglucose:				
Hypothalamic obese (25)	42–63	53 ± 12	101–149	125 ± 24
Normal Swiss controls (25)	24–32	29 ± 3	71–153	112 ± 41
Obese hyperglycæmic				
Obese (20)	49–62	55 ± 18	134–220	192 ± 24
Normal *V*-stock controls (30)	21–33	27 ± 6*	74–116	106 ± 10*
Adrenocorticotrophic hormone†				
Obese (13)	22–32	28 ± 4	121–133	127 ± 6
Normal LAF_1 controls (14)	24–30	27 ± 3	66–74	70 ± 4*
Yellow mice:				
Obese (17)	46–56	51 ± 5	116–212	164 ± 48
Normal controls (black) (14)	32–42	37 ± 5*	153–227	190 ± 37
Females:				
Obese (17)	48–60	54 ± 6*	153–227	190 ± 37
Normal controls (14)	32–36	34 ± 2*	114–168	141 ± 27*

* Difference significant at 1 per cent level.
† Mice of LAF_1 strain grafted with pituitary adrenocorticotropin-secreting tumours.

and by other enzymatic, endocrine, metabolic and behavioural idiosyncrasies. By contrast, goldthioglucose mice, which exemplify 'regulatory' obesity, namely, that type of obesity in which the hyperphagia is due exclusively to a lesion in the higher nervous centres controlling appetite, have normal levels of serum cholesterol. Regulatory forms of obesity are characterized by the fact that rates of lipogenesis and cholesterologenesis are brought back to normal levels when hyperphagia is eliminated and by the fact that body composition goes back to normal when weight is reduced to control levels.

The cholesterol picture of the yellow mice parallels the more complex sex-linked situation observed in these animals[6]: the female mice, which are characterized by much greater adiposity and rates of lipogenesis and cholesterologenesis higher than normal when fasted (unpublished work) are also characterized by high levels of cholesterol.

It thus appears that obese mice of different types suitably compared may offer particularly good material for the study of factors influencing the concentration of serum cholesterol and for the study of the influence of this on the development of lesions of atherosclerosis.

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Toxicity of a Cholinesterase Inhibitor to the Hibernating Hamster

METABOLIC activity is profoundly altered in the hibernating animal, as compared with that in the normal. Evidence is also available that under hibernating conditions nervous function in certain species can be affected[1]. Consequently it was of considerable interest to determine the toxicity of a ganglionic blocking agent to animals under the abnormal metabolic conditions produced by hibernation. The toxicity of the cholinesterase inhibitor O,O-diethyl-S-2-diethylaminoethyl phosphonothiolate[2] has been determined in the nornal and hibernating hamster by the intraperitoneal route.

Hibernation was induced by keeping the animals in the cold. A group of one hundred male animals weighing between 100 and 130 gm., were kept in individual cages in the cold room. The temperature was adjusted to ÷ 10° C. for the first week, then lowered to + 5° C. for the remainder of the experimental period. Animals were allowed 8 hr. of artificial light a day and disturbed as little as possible. Hibernation was induced in some animals as early as the sixth week and in others as late as the fifteenth week, by which time a total of forty animals had gone into hibernation. Inspection was carried out twice a day and toxicity determinations made 24 hr. after hibernation was first observed.

Handling of the animal, necessary for (intraperitoneal) injection, even if done with the greatest of care, initiates the waking mechanism, so that within a few hours the animal is active and apparently back to normal. Thus, strictly speaking, the results on toxicity refer to animals in the intermediate state between undisturbed hibernation and normal activity. Nevertheless, the rapid action of the inhibitor ensures that toxic symptoms are well established before a return to normal activity has been accomplished.

For each toxicity determination the inhibitor was made up afresh in anhydrous propylene glycol at a concentration of 1 mm.^{3}/ml., and an 'Agla' microsyringe was used for injection.

The *LD*50 determined on a normal group of 140 hamsters and calculated at the 5 per cent confidence limits by probit analysis was $0{\cdot}106+0{\cdot}006$ mm.^{3}/kgm. (intraperitoneal). The corresponding *LD*50 for the hibernating group was $0{\cdot}072 \pm 0{\cdot}012$ mm.^{3}/kgm. intraperitoneal.

The increased susceptibility of the hibernating group to the anticholinesterase is possibly a reflexion of the increased stress placed upon the animal by the cold environment or the metabolic readjustment necessitated by coming out of hibernation.

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Rate of Absorption of Supplementary Free Amino-Acids during Digestion

ANIMAL feeding studies have demonstrated that utilization of dietary protein is improved when an amino-acid deficiency is corrected by supplementation with free amino-acid. This greater utilization of protein is detected by the greater gain in body-weight of the test animal per unit of protein eaten, or by an increase in the percentage of ingested nitrogen retained by the animal. The improvement of the nutritive value of bread[1], rice[2] and maize[3] by supplementation with amino-acid has been demonstrated.

Although these investigations clearly point to nutritional improvement, supplementation of food proteins has been criticized on the grounds that the free amino-acids may be absorbed into the bloodstream before the amino-acids liberated by digestion of the protein. If this were so, the full value of the supplement would not be realized, since it has been demonstrated that efficient synthesis of tissue proteins occurs only when all the essential amino-acids are supplied simultaneously in the proper proportions[4].

The experiments reported here were designed to compare the rate of absorption of a free amino-acid supplement with that of the amino-acids liberated by digestion of protein. Healthy mongrel dogs were fasted for an 18-hr. period before being fed a meal containing the test protein. Approximately 25 ml. of blood was obtained by cardiac puncture of the unanæsthetized dog immediately before the meal (zero time) and 1, 2, 3, 4 and 5 hr. after the meal. (The feeding tests and the blood sampling were carried out at the Food and Drug Research Laboratories, Inc., under the direction of Dr. M. Brin.) The plasma was analysed for the essential amino-acids by ion-exchange chromatography[5], except for tryptophan, which was determined by microbiological assay employing *Lactobacillus plantarum*.

The concentrations in the plasma of several essential amino-acids after the ingestion of a wheat gluten diet for dog No. 364 (with and without a lysine supplement) are compared in Fig. 1. After the unsupplemented wheat gluten meal, the first limiting amino-acid, lysine, shows a marked decrease. Typical non-limiting amino-acids, such as threonine and tryptophan, show a gradual increase and then a decrease during the five hours after the meal. The decrease in concentration of lysine indicates that some of the lysine reserve of the plasma is used up to allow partial utilization of the other essential amino-acids from the wheat gluten. This finding may explain why the determinations of biological value for low-quality proteins sometimes give higher values than would be expected from their amino-acid composition[6]. Apparently, the plasma can serve as an amino-acid reservoir and supply a limited amount of an amino-acid which is deficient in the protein ingested. Further amounts of limiting amino-acids may also be mobilized by depletion of the stores of labile protein. Therefore, in short-term studies a greater utilization of the dietary protein for tissue synthesis will be obtained than would be possible if the only amino-acid source were the food protein itself.

When wheat gluten supplemented with lysine is fed (2 gm. L-lysine monohydrochloride per 100 gm. protein, which is the optimum supplementation-level for bread determined by animal-feeding studies; ref. 1), the concentration pattern of the plasma lysine after the meal is similar to the pattern exhibited by the non-limiting essential amino-acids (see Fig. 1). Only threonine and tryptophan are shown in Fig. 1, but all the non-limiting essential amino-acids gave similar patterns. These results indicate a similar rate of absorption for the 'free' lysine and the amino-acids from the wheat gluten. This is evident because the increase in the concentration of plasma lysine would not extend over the first two hours after the meal nor would the lysine concentration be maintained as well after five hours if the 'free' lysine were absorbed at a markedly faster rate than the amino-acids from the protein.

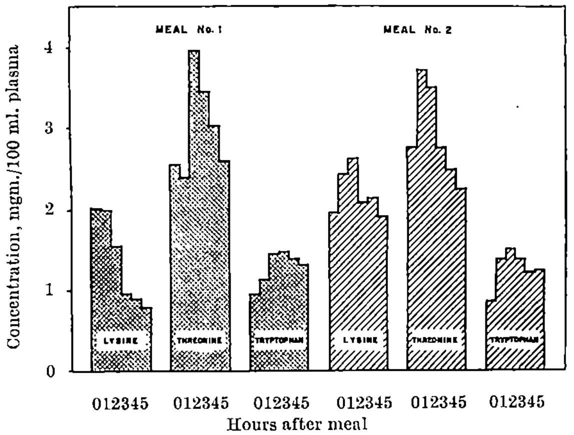

Fig. 1. Changes in blood plasma amino-acid after the ingestion of wheat gluten with and without L-lysine. Meal No. 1 contained 84·9 gm. wheat gluten (13·23 per cent nitrogen), 95·1 gm. sucrose, 20 gm. cottonseed oil and approximately 150 gm. water. Meal No. 2 contained 84·9 gm. wheat gluten, 1·3 gm. L-lysine-monohydrochloride, 93·8 gm. sucrose, 20 gm. cottonseed oil and approximately 150 gm. water

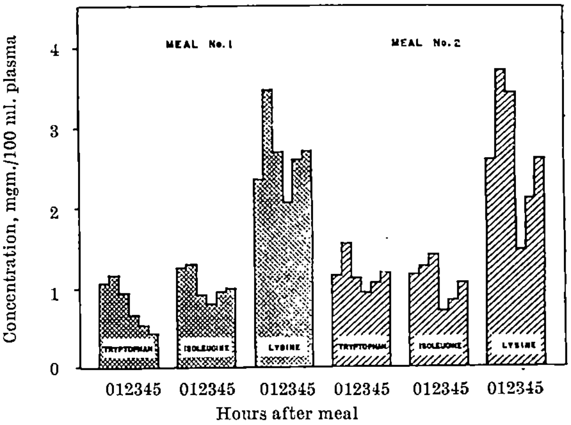

Fig. 2. Changes in blood plasma amino-acid after the ingestion of gelatin with and without L-tryptophan. Meal No. 1 contained 70·5 gm. gelatin (14·52 per cent nitrogen), 109·5 gm. sucrose, 20 gm. cottonseed oil and approximately 150 gm. water. Meal No. 2 contained 70·5 gm. gelatin, 0·3 gm. L-tryptophan, 109·2 gm. sucrose, 20 gm. cottonseed oil and approximately 150 gm. water

An identical experiment was carried out on gelatin with and without supplementation with tryptophan using dog No. 365. The results are presented in Fig. 2. The tryptophan deficiency is revealed by a decided lowering of the concentration of plasma tryptophan after a gelatin meal. When this deficiency is corrected by addition of free tryptophan to the gelatin (0·5 gm. L-tryptophan per 100 gm. protein), the plasma tryptophan pattern after the meal is similar to the patterns of the other non-limiting essential amino-acids. This indicates that the free tryptophan is absorbed into the blood at a rate similar to that of the amino-acids from the gelatin.

Thus direct studies *in vivo* indicate that the addition of a free amino-acid to a protein is a practical method of overcoming an amino-acid deficiency of the protein. Since the amino-acid deficiency in the blood is corrected at the time when the other essential amino-acids are present at their maximum concentrations, optimum utilization of the essential amino-acids from the protein should be realized.

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Significance of Urinary Vanillic Acid

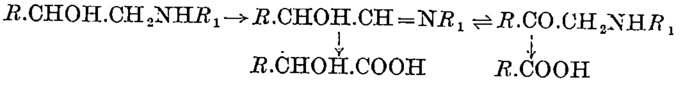
As a result of the observation that vanillic acid was excreted in abnormal quantities by some subjects exposed to stress, Smith and Bennett[1] suggested that the substance might be a metabolite of adrenaline or noradrenaline. In a recent communication[2] Shaw and Trevarthen considered these conclusions to be unjustified, since natural dietary precursors of the acid exist ; in particular these authors found increased excretion of vanillic acid by one subject following ingestion of coffee. We therefore wish to emphasize that we were well aware of these facts long before we even observed high values in stress and carefully considered them before allowing our conclusions to appear in print ; in point of fact I postulated that vanillic acid might be an adrenaline metabolite so long ago as 1954, but was for some time unable to obtain sufficiently unambiguous confirmatory evidence, since the technical imperfections of chromatographic methods coupled with the variations in excretion-rate observed in normal subjects were sufficient to mask any changes that may have occurred using other conditions of stress. A further experiment, which did not in fact confirm a high excretion of vanillic acid in driving-stress, has been the subject of a recent communication[3].

However, other observations, mostly of a rather scattered nature, have served only to convince us that the substance may arise endogenously, and an origin from adrenaline or noradrenaline is the only explanation we are able to offer. It must be admitted, though, that direct and conclusive evidence has not been easy to obtain. Thus in an experiment in which adrenaline was infused intravenously into a subject, vanillic acid was conspicuous in being one of the very few urinary phenols which was *not* excreted at an enormously increased rate, possibly as the result of diuresis. Since in any event the metabolism of, say, intravenously infused adrenaline may by no means be identical with the metabolism of adrenaline released from the adrenals, we have preferred to base our conclusions on inferences deduced from studies of excretion despite the pitfalls that may arise because of the practical impossibility of controlling diet.

It is indeed true that much—probably most—of the vanillic acid in normal urine is of exogenous origin. This is only to be expected since the normal rates of secretion of the sympathomimetic amines cannot be very high. However, in our British subjects most of whom rarely drink coffee, the rate of excretion of vanillic acid is rather low. On the few occasions when quantities approaching those observed in stress have been noted in normal subjects, other metabolites of caffeic and chlorogenic acids have been equally evident ; these acids are probably quantitatively by far the most important exogenous source of vanillic acid. Studies on the metabolism of caffeic and its related acids have been carried out intermittently in these laboratories over a period of some five years ; even so, we have not as yet been able to reach definite conclusions. Differences between the observations of Shaw and Trevarthen[2] and of Booth *et al.*[4], and between both these groups and ourselves concerning the metabolites detected after administration of coffee, for example, seem to be too significant to be readily explained away by possible variations in the source of the coffee. Some degree of clarification has been achieved since we now believe that methylation of 3 : 4-dihydroxyphenyl groups on the 4- as well as on the 3-position occurs far more generally than has been previously indicated[1,4], and some previously published observations may require modification. For example, if our experience is any guide, the increased excretion of vanillic acid after coffee noted by Shaw and Trevarthen[2] may be perhaps somewhat exaggerated since using the chromatographic technique employed by these authors we would expect to observe not vanillic acid alone, but a composite spot consisting of vanillic, *iso*vanillic and *iso*ferulic acids, in varying proportions according to the subject.

The dietary origin of much of the aromatic material in urine has been confirmed in these laboratories. Four urine samples were collected during the morning from each of seven subjects who had had no breakfast. As anticipated, the rates of excretion of many substances progressively diminished during the course of the experiments. In two subjects, however, well-defined increases in vanillic acid were observed in the acid-hydrolysed urines. In each case corresponding chromatograms of the unhydrolysed urines showed a parallel increase in 4-hydroxy-3-methoxymandelic acid. Since the latter compound is known to be a metabolite of noradrenaline[5,6], the experiments therefore indicate not only that vanillic acid may be formed endogenously but also support the suggestion of Smith and Bennett[1] that it is a metabolite of adrenaline or noradrenaline.

While there can be no doubt that the high values reported for vanillic acid were well beyond the normal range, the interpretation that the acid is a metabolite of adrenaline or noradrenaline is much less certain. In the first place, equally well-defined changes in the excretion of 3-ethoxy-4-hydroxybenzoic acid have now been reported in stress[3]. In view of the close chemical relationship of this substance to vanillic acid it would surely be too much of a coincidence if the increased excretion of both compounds had not a common basis. Until the possibility of biological ethylation has been clearly demonstrated the suspicion must therefore arise that both acids might have arisen because of the ingestion of sweets or other foodstuffs flavoured in some cases with vanillin, in others with ethyl vanillin. However, every care was taken to check that this was not so ; in the case of the two subjects discussed previously[3] the possibility can certainly be excluded. In the second place, the formation of vanillic acid from the phenylethanolamines requires a plausible, if hypothetical, metabolic pathway. Consideration of the likely properties of possible intermediates has led us to favour a scheme represented in its simplest form by :



$$\begin{array}{ccccc} R.\mathrm{CHOH.CH_2NH}R_1 & \rightarrow & R.\mathrm{CHOH.CH{=}N}R_1 & \rightleftharpoons & R.\mathrm{CO.CH_2NH}R_1 \\ & & \downarrow & & \downarrow \\ & & R.\mathrm{CHOH.COOH} & & R.\mathrm{COOH} \end{array}$$

It is therefore of interest that in a preliminary experiment, oral administration of adrenalone (3 : 4-$(\mathrm{OH})_2$ $\mathrm{C_6H_3.CO.CH_2NHCH_3}$) to a human subject has been found to result in the excretion of grossly abnormal quantities of vanillic, *iso*vanillic and 4-hydroxy-3-methoxymandelic acids. In the guinea pig, injection of either adrenaline or adrenalone has been reported to yield the same metabolite, believed to be protocatechuic aldehyde[7].

I wish to thank Mrs. G. A. Hill and Mr. J. Ratcliffe for experimental assistance.

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Local Reaction to Non-metastasizing and Metastasizing Transplantable Tumours

The mechanism by which tumours spread into the surrounding tissues or produce metastases in distant organs is still an obscure problem. The reaction of the tissues of the host in relation to the rate of growth and metastasization has not been sufficiently investigated.

Bottiglioni and Prodi[1] observed that only the stroma of metastasizing tumours is rich in a metachromatic substance.

The present investigation aimed at studying the local reaction to non-metastasizing and metastasizing transplantable tumours, namely, the Walker adenocarcinoma and a rat sarcoma (non-metastasizing tumours at expansive growth), rat tumour Guérin *T*58 (non-metastasizing, in our strain, at infiltrative growth), rat tumour Guérin *T*8 (metastasizing, lymphotrope) and the rabbit Brown Pearce tumour (which produces metastases in lymph nodes and parenchymatous organs).

The tumours were transplanted with the usual technique, those of the rat subcutaneously, and the Brown Pearce tumour in the testis. The animals were killed when tumours had attained maximal development. Both primary tumours and metastases, when present, were removed with their surrounding tissue and studied with appropriative connective tissue stainings.

Investigations were carried out on material from sixty-five animals.

Around the grafts of Walker adenocarcinoma and rat sarcoma no connective tissue reaction was macroscopically detected; microscopically, the boundaries between tumour cells and host tissue are well outlined. The host tissue shows a considerable number of mast-cells, forming a sort of barrier around the tumour mass. Some of these cells are degranulated, some packed with granules. The fibroblastic reaction is rare.

Tumour *T*58 seems to become identified with the adjacent tissues. Its cells penetrate into the dermis and muscle, directly replacing the tissues without any kind of reaction.

Around tumour *T*8, in both the primary site and particularly around the metastases in superficial lymph nodes, a layer of loose connective tissue, sometimes of a mucous type, is observed; this tissue is rich in fibroblasts, and the loose fibrillar texture assumes a clear-cut metachromatic colour when stained with toluidine blue. Here and there the tissue takes the aspect of a thin extracellular network which shows intense metachromasia. If sections are pretreated with hyaluronidase, metachromasia does not occur. The mast-cells are scanty. Many round-shaped structures, which apparently are hectasic lymphatic vessels, are observed. The connective tissue is infiltrated with tumour cells which occasionally are also seen inside the lumen of these vessel-like structures.

Both around the primary tumour and the metastases (in the liver, kidney, lung, lymph nodes and peritoneal membranes) of Brown Pearce tumour an intense connective tissue reaction is observed with a large amount of highly metachromatic substance, which is destroyed by pretreatment with hyaluronidase. The tissue is of a loose fibrillar type, with often numerous fibroblasts and infiltrated with tumour cells.

The presence of a mast-cell barrier around the grafts of Walker adenocarcinoma and rat sarcoma which do not metastasize and grow extensively may indicate a defence against infiltration: such a hypothesis has already been suggested by Sylvén in relation to skin carcinogenesis[2]. This observation seems to be confirmed by the fact that there is little or no such reaction around tumour *T*58, which is infiltrative.

As regards metastasizing tumours, the tissue reaction is represented by a loose connective tissue which does not change into thickly fibrous tissue. This, with some differences, is a common character of the Brown Pearce and the *T*8 tumours. The reaction of connective tissue interposed between host and tumour tissue forms a sort of third section which is easily invaded by tumour cells and which, being rich in vascular formations (which are particularly evident around *T*8 tumour), facilitates their passage into the circulation and consequently the onset of metastases.

These considerations suggest that the rate of growth as well as the ability to induce metastases may not be directly dependent upon intrinsic characters of the cell but rather upon the reaction induced and established by the tumour cell in the host tissue.

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Changes in the Potassium Concentration and Metabolism of Red Blood Cells of the Lamb

Many investigations have been made attempting to relate the potassium content and transport in red blood cells to the glycolytic activity of the cells[1,2]. Such investigations have utilized red blood cell suspensions which have been stored at low temperatures in order to obtain partial depletion of the cells with respect to potassium.

Widdas[3] has shown that the potassium content of fœtal sheep red blood cells is considerably higher than that found in the mature animals of the same breed. At birth the potassium concentration in the cells is high and decreases with increasing age of lamb. Thus successive samples of red blood cells from the same lambs can produce systems in which marked differences in the concentration gradient $(K^+)_i/(K^+)_o$ exist.

In preliminary experiments, we have made measurements of the potassium and sodium content, oxygen uptake and glycolytic activity of red cells obtained from lambs over the period 12–60 days of age.

Venous blood samples were taken into heparin, centrifuged, the red blood cells isolated, washed with

Table 1

Lamb No.	Age (days)	[Na⁺] m.equiv./l. Initial	[Na⁺] m.equiv./l. Final	[K⁺] m.equiv./l. Initial	[K⁺] m.equiv./l. Final	Q_{O_2}	$Q_{\text{lactic acid}}$
1	14	41	38	95	95	0·033	—
	31	120	104	23	25	0·024	0·34
	44	117	116	11	11	0·014	0·49
	63	125	119	3	3	0·013	0·17
2	12	56	60	82	77	0·021	—
	29	99	92	32	34	0·011	0·35
	42	109	100	24	24	0·012	0·45
	61	108	103	7	7	0·011	0·26
3	13	67	54	76	81	0·020	0·47
	26	92	94	37	39	0·015	0·53
	45	112	110	6	6	0·012	0·24
4	13	77	67	74	78	0·019	0·37
	26	107	97	40	39	0·017	0·45
	45	115	111	5	5	0·012	0·25

phosphate buffer solution (1·5 ml. $M/2$ potassium dihydrogen phosphate, 8·5 ml. $M/2$ disodium hydrogen phosphate, 240 ml. 0·9 per cent sodium chloride, glucose $M/100$) and resuspended in an equal volume of the same medium. After preliminary incubation to allow complete oxygenation, samples were taken for measurement of the initial potassium and sodium contents of the cells and lactic acid content of the medium. Replicate samples were then incubated (37° C.) for 2 hr. in a Warburg apparatus with air as the gas phase, when final estimations of potassium, sodium and lactic acid content were again made. Potassium and sodium were measured directly from centrifuged cells using a Beckman flame photometer; lactic acid contents of the media were measured by the method of Barker and Summerson[4].

The results are shown in Tables 1 and 2. Within the period 12–60 days of age, in each of the lambs used, large decreases in red cell potassium content were observed whereas the sodium content rose appreciably. Uptake of oxygen by the red cells decreased with increasing age of the lambs but no regular trend was observed with respect to lactic acid production by the same cell samples. Incubation in the presence of iodoacetate resulted in great reduction in the lactic acid production without change in the cell potassium content. In anaerobic conditions (oxygen-free nitrogen as gas phase and chromous chloride in centre wells of flasks), however, the red cells lost an average of 17 per cent of their potassium in 3 hr.

Table 2

Lamb No.	Age (days)	Incubation conditions	[Na⁺] (m.equiv./l.) Initial	[Na⁺] (m.equiv./l.) Final	[K⁺] (m.equiv./l.) Initial	[K⁺] (m.equiv./l.) Final	$Q_{\text{lactic acid}}$
1	14	Control	79	77	44	44	0·44
		0·001 M IAA	79	79	44	46	0
2	14	Control	86	85	44	41	0·42
		0·001 M IAA	86	87	44	39	0·02
3	14	Control	81	76	46	46	0·33
		0·001 M IAA	81	81	46	47	0·01
4	14	Control	84	84	42	48	0·37
		0·001 M IAA	84	84	42	42	0
1	14	3 hr. N_2 + 0·001 M IAA	87	89	43	36	0·04
2	14	3 hr. N_2 + 0·001 M IAA	53	58	83	67	0·02
3	13	3 hr. N_2 + 0·001 M IAA	90	91	49	43	0·02
4	12	3 hr. N_2 + 0·001 M IAA	74	86	53	41	0

Thus there appears to be little correlation between the potassium retention and glycolysis, but rather more between oxidative metabolism and maintenance of the potassium content of the cells.

Consideration of the changes observed in intracellular potassium concentration with age compared with the concomitant changes in total metabolic activity indicates that while decreases in potassium concentration of the order of 90 per cent occurred, oxygen usage declined to about half, and glycolytic activity to a slightly less extent.

Thus it is suggested that red blood cell suspensions such as these, in which large changes in intracellular potassium and sodium concentrations occur naturally, may provide more suitable material for investigations attempting to relate potassium retention to other cellular characteristics. Particularly indicated are studies involving the use of radioactive potassium, which is not available in sufficient activity in Australia, to estimate the degree of dependence of potassium transport and concentration on the metabolic activity of lamb red blood cells.

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Serum Lipoproteins and Blood Coagulation

INHABITANTS of the highlands of New Guinea eat very little fat in their diet, have low levels of serum cholesterol, and rarely suffer from coronary heart disease[1]. This is in accord with experiences in other primitive races, and contrasts sharply with what is found among Australians and others of European origin, thus providing indirect support for the lipid infiltration theory of atherogenesis. With the thrombogenic theory in mind it would be valuable to gather information about coagulability of blood in different races, and this, to a limited extent, has been done in Australia and New Guinea.

Observations show that blood clots faster in natives than in Australians. The average whole-blood clotting times measured in duplicate in siliconed glass tubes were 26·6 and 28·6 min., respectively ($P < 0·01$), and the Stypven times (recalcified platelet-poor plasma accelerated with Russell's viper venom) were 41·4 and 72·2 seconds ($P < 0·001$). There was no significant correlation between these two clotting tests, and neither bore any relation to the levels of serum cholesterol or phospholipids. However, further analysis suggested that Stypven times were markedly affected by the serum lipoproteins. This was the case in both the aborigenes and Australians (40 and 26 men respectively) and accounted in part for the overall difference between the two racial groups. The lipoprotein fractions were measured as milligrammes of cholesterol eluted from paper strips after electrophoresis[2]. The partial correlation coefficient for Stypven time and alpha-cholesterol was positive and highly significant: on the other hand, the coefficient for Stypven time and beta-cholesterol was negative but not significant. The regression relationships were as follows: Stypven time (sec.) $= 50{\cdot}51 + 0{\cdot}80\alpha - 0{\cdot}8\beta$ for the Australians, and $40{\cdot}32 + 0{\cdot}46\alpha - 0{\cdot}09\beta$ for the natives.

The results offer no direct support for a thrombogenic factor in coronary heart disease, but they do suggest that a constituent of alpha-lipoprotein delays clotting in the Stypven test. Whatever may be the nature of this inhibiting factor, there is evidence to suggest that it is not cholesterol itself[3]. In order to confirm these observations further study of the effects of the specific phospholipid and fatty acid constituents of alpha-lipoprotein on the Stypven system will be necessary.

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Effect of Diphosphopyridine Nucleotide on the Inhibition of Rat Liver 3-Hydroxyanthranilic-Acid Oxidase by 2-Acetylaminofluorene and N-2-Fluorenyl-diacetamide

Dunning *et al.*[1] demonstrated that bladder cancer due to 2-acetylaminofluorene was produced in almost all rats (strain Fisher 344) on a diet containing large quantities (1·4–4·3 per cent) of tryptophan. On the other hand, rats on a diet containing smaller amounts of tryptophan did not develop bladder cancer. We showed that the administration of 2-acetylaminofluorene inhibits 3-hydroxyanthranilic-acid oxidase in rat hepatic tissue[2], with consequent accumulation of the two carcinogenic *o*-aminophenolic compounds 3-hydroxyanthranilic acid and 3-hydroxykynurenine[3]. It seemed of interest to pursue these studies in order to elucidate the mechanism of this inhibition.

Kielley[4] has demonstrated that several carcinogenic fluorene compounds inhibit glutamic dehydrogenase; N-2-fluorenyl-diacetamide would therefore act by blocking the utilization of diphosphopyridine nucleotide[5]. In view of this, it seems probable that 2-acetylaminofluorene inhibits 3-hydroxyanthranilic-acid oxidase by affecting the utilization of diphosphopyridine nucleotide (which seems to take part in the reaction[6]). In order to test this hypothesis, we performed new experiments with 2-acetylaminofluorene and N-2-fluoroenyldiacetamide.

Livers, from rats of unspecified strain weighing about 200 gm. and which had received 0·1–0·2 per cent of Hoffmann–La Roche 2-acetylaminofluorene in their diet (Coward) for 2–6 days, were used. The liver was excised, immediately homogenized in the cold in a Potter blendor with Krebs–Ringer phosphate (3 ml. per gm. of tissue), and centrifuged. The supernatant was used as enzyme source.

The incubation mixtures had the following composition: 1 ml. of supernatant; 3,000 μgm. 3-hydroxyanthranilic acid (Hoffmann–La Roche) diphosphopyridine nucleotide (I.S.I.) at a final concentration of 2×10^{-5} *M* (made up to final volume of 6·34 ml. with Ringer's solution). At the same time mixtures without diphosphopyridine nucleotide, without 3-hydroxyanthranilic acid and without tissue were prepared. The mixtures were incubated at 37° C. for 90 min. with frequent shaking.

Quinolinic acid was determined according to the method of Rabinovitz *et al.* with slight modifications[7].

Livers of rats of the same strain, weight and age, which had received the same diet, but without 2-acetylaminofluorene, were assayed for their ability to convert 3-hydroxyanthranilic acid into quinolinic acid under identical experimental conditions.

In one experiment 546 μgm. of quinolinic acid was formed in the presence of normal rat liver (diphosphopyridine nucleotide does not affect this enzymatic activity); 273 μgm. quinolinic acid was formed in the presence of liver from a rat treated with 2-acetylaminofluorene (diphosphopyridine nucleotide added to these incubation mixtures brings the enzymatic activity almost back to normal).

In other experiments we studied the 3-hydroxyanthranilic-acid oxidase activity in rats treated with parenteral injections of N-2-fluorenyl-diacetamide (for which we thank Prof. Kielley and Prof. Weisberger) and the effect of diphosphopyridine nucleotide on this activity *in vitro*. Rats weighing about 200 gm. were treated for four days parenterally with N-2-fluorenyl-diacetamide (40 mgm. in 2 ml. of sterile olive oil per day); on the fifth day the treated animals and the controls, which received 2 ml. of olive oil per day for four days, were killed by decapitation and the 3-hydroxyanthranilic-acid oxidase in the liver determined as described above.

In one experiment 525 μgm. of quinolinic acid was formed in the presence of normal rat liver (diphosphopyridine nucleotide does not potentiate this enzymatic activity); 315 μgm. of quinolinic acid was formed in the presence of liver from a rat treated with N-2-fluorenyldiacetamide (diphosphopyridine nucleotide added to these incubation mixtures brings the enzymatic activity back to normal).

Thus, *in vitro*, diphosphopyridine nucleotide abolished the inhibition of rat liver 3-hydroxyanthranilic-acid oxidase produced by 2-acetylaminofluorene and N-2-fluorenyldiacetamide.

Our work therefore confirms Kielley's[4,5] on the inhibitory influence of fluorene carcinogens on the utilization of the pyridine coenzymes. Moreover, these investigations lead to the following important suggestion: the inhibition of 3-hydroxyanthranilic-acid oxidase is observed both in hepatic tissue of rats bearing Oberling, Guérin and Guérin myeloma at the leukæmic phase[8] and in the hepatic tissue of rats treated with 2-acetylaminofluorene and N-2-fluorenyldiacetamide. In both cases this inhibition is abolished by diphosphopyridine nucleotide.

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A Bucco-hypophysial Canal in *Elops saurus*

A PERSISTENT Rathke's pouch in the form of a hollow bucco-hypophysial canal piercing the parasphenoid bone has been reported in young animals and adults of the two recent brachiopterygian genera *Calamoichthys*[1] and *Polypterus*[2,3]. The recent coelacanthid *Latimeria* is reported to possess a partly hollow cord of glandular tissue running from the adenohypophysis towards the roof of the mouth cavity[4]. Besides, there is a canal in the parasphenoid, but this canal, which is regarded as a vestige of Rathke's pouch, does not reach the fossa hypophyseos[5]. In the early fossil coelanthids the fossa hypophyseos is in communication with the mouth cavity by means of a canal piercing the parasphenoid and the same is true of the Devonian rhipidistid crossopterygians[6]. In the fossil actinopterygians this communication is rarely retained and has been observed in a few instances only[7-9]. In the recent actinopterygians it has been hithorto unknown.

It was very surprising, therefore, to find a wide canal connecting the pituitary and the oral epithelium in young individuals of the primitive teleost *Elops saurus* (Fig. 1). No doubt this canal, which strongly resembles that of *Polypterus*, represents a rudiment of the original pharyngeal pouch.

The canal originates at the anterior end of the adenohypophysis from several follicle-like pockets, which contain tall cells, apparently with glandular properties. In its proximal part, the canal is directed straight ventralwards until it reaches the parasphenoid. There the lumen becomes narrower and the canal turns at right angles rostrally and slightly ventrally, before passing obliquely through the parasphenoid. Underneath this bone the canal opens into the pharynx as an elongated but rather narrow cleft.

The bucco-hypophysial canal is lined by a single-layered squamous epithelium, which nowhere carries cilia, in contrast to the condition in *Polypterus*, where a strongly ciliated region is found around the opening into the pharynx. The whole apparatus strongly suggests a mechanism for external secretion ; but no trace of secretion could be seen in the canal lumen of the specimens investigated.

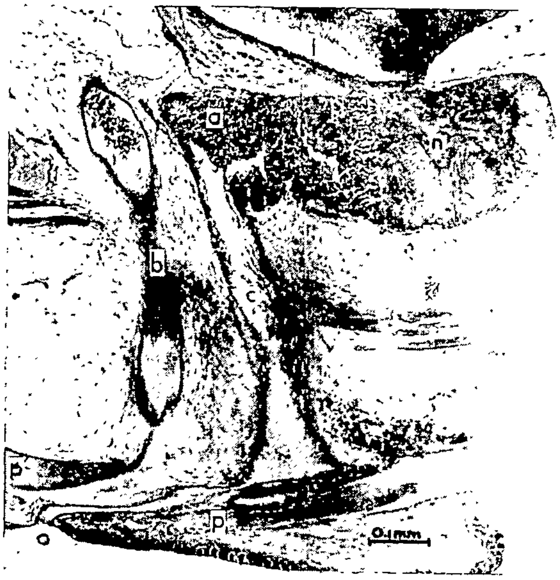

Fig. 1. *Elops saurus*, 60 mm. median section through the pituitary region showing : *a*, adenohypophysis ; *b*, blood vessel ; *c*, bucco-hypophysial canal ; *i*, infundibulum ; *n*, neurohypophysis ; *o*, canal opening into the pharynx ; *p*, parasphenoid

There can be scarcely any doubt that the existence of a persistent communication between the pituitary and the roof of the pharynx is an archaic feature, which may possibly even recall the condition in the ascidians[10]. Anyhow, this observation further strengthens the opinion[11] that the members of the family Elopidae are the most archaic of the recent teleosts. At the same time it recalls the recent suggestion[12] that the elopids are holosteans rather than teleosts.

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Soluble Nucleotides and Nucleotide–Amino-Acid Compounds of Yeast

AN investigation of the soluble nucleotides in food yeast (*Torulopsis utilis*) has shown that a complex metabolic pool of these compounds is maintained in growing cells. Marked changes in the size and composition of this pool under different physiological conditions indicate that the metabolism of nucleotides is closely related to the biosynthesis of nucleic acids and proteins. Some evidence has been obtained that, in exponentially growing cells, certain of the nucleotides occur in combination with amino-acids or simple peptides.

Soluble nucleotides were extracted from yeast by means of ice-cold 60 per cent ethyl alcohol. After removal of the solvent by evaporation *in vacuo*, and filtration to free the extract from lipid material, the nucleotides were separated by column chromatography on the basic exchange resin 'Dowex-1' (× 10). The general method of preparation and operation of the column followed that of Brumm, Potter and Siekevitz[1], except that the elution gradient was steepened by reducing the mixing volume in two stages. In this way, improved separation and sharper peaks were obtained in the later stages of elution. A typical example of the separations achieved by this method is shown in Fig. 1. Identification of the nucleotide peaks is based on co-chromatography with pure compounds, where available, and on measurements of ultra-violet absorption spectra under acid and alkaline conditions.

The elution pattern shown has been consistently observed when cells, in the exponential phase of growth, were rapidly separated from the culture medium by filtration and immediately treated with ice-cold absolute alcohol. Prompt harvesting and fixation are important, since otherwise marked changes occur in the nucleotide pool. For example,

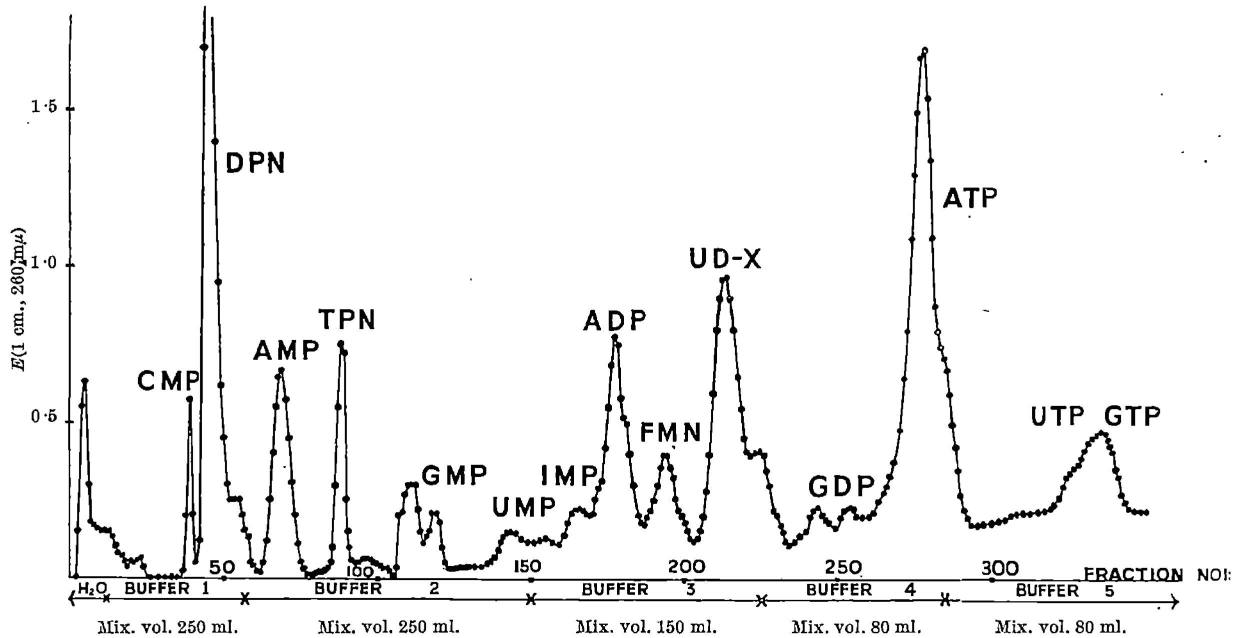

Fig. 1. Soluble nucleotides of *Torulopsis utilis*. Extract from 1·56 gm. fresh yeast eluted from 'Dowex-1' (formate) 200–400 (×10); column 16 × 1·5 cm.; fractions 3·7 ml. Buffers: (No. 1), 1 *N* formic acid; (2), 4 *N* formic acid; (3), 4 *N* formic acid – 0·2 *M* ammonium formate; (4), 4 *N* formic acid – 0·4 *M* ammonium formate; (5), 4 *N* formic acid – 0·8 *M* ammonium formate.

AMP, ADP, ATP, adenosine 5′ mono-, di- and tri-phosphates; UMP, UDP, UTP, uridine 5′ mono-, di- and tri-phosphates; GMP, GDP, GTP, guanosine 5′ mono-, di- and tri-phosphates; CMP, cytidine 5′ monophosphate; IMP, inosine 5′ monophosphate; DPN, TPN, di- and tri-phosphopyridine nucleotides; FMN, flavin mononucleotide

cells harvested less rapidly by centrifugation contain much larger quantities of the monophosphates inosine 5′ monophosphate and uridine 5′ monophosphate.

The composite peak, uridine 5′ diphosphate-*X*, has only been found in extracts prepared from exponentially growing cells; it undergoes a sharp decline if the culture is harvested by centrifugation. Examination of the peak has shown that on hydrolysis with 1 *N* acid it yields four amino-acids, which have been identified by column and paper chromatography as aspartic acid, glutamic acid, arginine and alanine. It has not been possible to separate the nucleotide and amino-acid components by purification on the acidic resin, 'Zeokarb 225', on charcoal, or by paper electrophoresis.

A more thorough investigation of the uridine 5′ diphosphate-*X* peak is now in progress, and an attempt is being made to estimate the rate of turnover of the constituent amino-acids by means of substrates labelled with carbon-14. Thus more decisive evidence may be gained of the significance of these constituents in the synthesis of peptides and proteins in yeast and of their relation to similar nucleotide compounds which have been detected in other micro-organisms[2-5].

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Root Nodules in *Discaria toumatou* Raoul Choix

Discaria toumatou is a thorny shrub belonging to the Rhamnaceae. It is endemic in New Zealand and is common in mountain valleys on the eastern side of the Southern Alps. The root systems of plants growing in a number of widely separated localities in the South Island have been examined and all have been found to be nodulated.

Fig. 1 shows the nodules which by continuous dichotomous branching give rise to coralloid clusters. Morphologically they have a number of features in common with previously described non-leguminous nodules[1]. They represent modified roots, in which there is no distinct apical meristem and with many of the cortical cells enlarged and occupied by an endophyte. In infected cells immediately below the apex the endophyte appears to be filamentous. Sections cut farther down show that the endophyte produces bunches of vesicles approximately 4μ in diameter. In fresh preparations mounted in water, these bunches can be freed from the host cells by squashing and some of the vesicles become detached together with a short length of hypha-like connecting strand. Nuclei in infected cells are large and misshapen. In the basal regions of the nodule branches there is a zone in which the contents of the infected cells are more amorphous and appear to be undergoing degeneration.

The taxonomic position of *Discaria* in relation to other genera with root nodules is of interest. In the Rhamnaceae, there is another genus, *Ceanothus*, known to have nodules. All three genera of the Eleagnaceae have been found nodulated and Hutchinson[2] places this family together with the Rhamnaceae in a common order, the Rhamnales. This group, then,

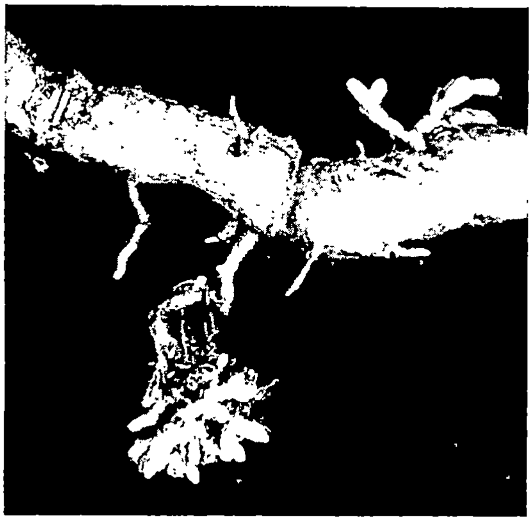

Fig. 1. Nodules on *Discaria toumatou*. (Actual size)

contains five of the nine non-leguminous dicotyledonous genera which have been reported to bear nodules of the general type described here.

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Application of Autoradiographic Techniques to Studies of Shoot Apices

In contrast to the earlier widely accepted concepts of the structure and growth of the shoot apex, Buvat and his associates[1–3] have proposed an alternative interpretation. According to this newer view the most apical, axial cells of shoot apices in a variety of plants do not have histogenic or organogenic roles during vegetative growth. The criterion of activity was based on the frequency of mitosis. This information was obtained by counting mitotic figures in various zones of the shoot apex and then presenting this information in the form of a composite diagram. The results of these investigations have been challenged by Gifford[4] and by Popham[5]; the latter used essentially the same methods as did the French workers.

It would seem, then, that more definitive evidence is necessary before any final conclusions can be drawn. The existing results are limited largely by the techniques used. The simple counting of division figures as an indication of local frequencies of mitotic activity has several drawbacks, including possible periodicity, either local or general. Also, mitotic frequency diagrams are meaningful only if the cell size is relatively uniform in the areas which are being compared. However, this is not the case in shoot apices. Therefore, new techniques must be applied to a more thorough analysis of the problem.

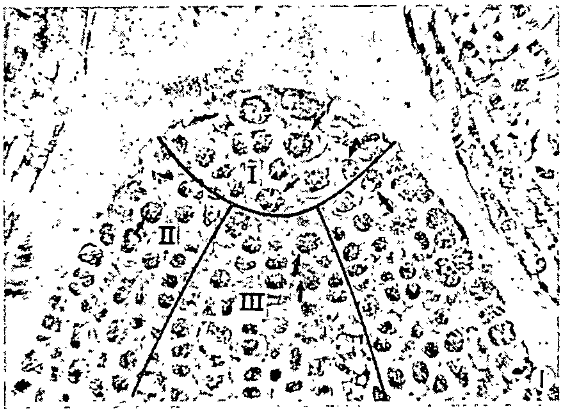
A suggestion of a new approach came from the recent work of Clowes[6] on the localization of nucleic acid synthesis in root meristems by using autoradiographic techniques.

In our present investigations we have applied the autoradiographic localization of nucleic acid synthesis to shoot apices, using phosphorus-32 in the form of inorganic phosphate as the labelling substance. Several plant species were exposed to concentrations of phosphorus-32 ranging from 10 to 50 μc./ml. by immersing either the cut terminal portions (approximately 6–8 in. long) or the roots of the intact plants in Hoagland's solution with phosphorus-32 added, for periods of 1–7 days. Shoot tips were then fixed in formalin–acetic alcohol, dehydrated, embedded in paraffin and sectioned at 8–10μ. Using high-resolution stripping film ('Kodak' Fine-Grain Autoradiographic Stripping Plate *AR*. 10), the technique as outlined by Taylor and McMaster[7] was employed. The prepared autoradiographs, in which the sections and the film are permanently superimposed and in register, were mounted in an oil with a refractive index approximating that of the unstained sections, thus minimizing the light scatter by the section while the autoradiographic image was photographed by dark-field illumination. Then, without changing the stage setting of the microscope, xylol was injected under the coverslip to lower the refractive index of the mounting medium, thus producing a more intense phase-contrast image to permit the photographing of the section.

In this preliminary report we shall confine our observations to just one of the species investigated—namely, *Pinus lambertiana*. Fig. 1 shows the phase-contrast image of a median longitudinal section of the shoot apex and Fig. 2 the corresponding autoradiograph. This shoot was exposed to phosphorus-32 solution for a period of three days, and the section was extracted according to the schedule of Taylor and McMaster, using finally a hydrolysis in *N* hydrochloric acid at 60° C. for 12 min. to remove the ribonucleic acid. After this treatment the major part of the radioactivity is due to the phosphorus-32 incorporated into newly synthesized deoxyribonucleic acid, with some possible activity in proteins.

Cytological zonation of the apex is evident in Fig. 1, namely, a terminal zone (I) consisting of large vacuolate cells with correspondingly large nuclei, a peripheral zone (II) of smaller cells and a central column of rib meristem (III). For convenience of presentation, zone I includes apical initials and central mother zone, an organization frequently recognized by others. According to the French workers the site of intense mitotic activity is in the upper portion of the peripheral zone, which they assume to be self-perpetuating, with little or no activity in the terminal zone. Although no division figures are evident in Fig. 1, there is evidence of synthesis of deoxyribonucleic acid, as shown in Fig. 2. Some of these centres of high radioactivity, as indicated by the dense clusters of silver grains, clearly fall within the terminal zone. These centres can be seen to coincide with nuclei in Fig. 1. There are certain highly refractive areas in the developing pith and in the leaves which over-arch the apex; these are not to be confused with light scatter due to exposed silver grains in the emulsion.

The presence of synthesis of deoxyribonucleic acid, as evidenced by the incorporation of radioactive label, can be taken to be indicative of subsequent mitotic activity, in the absence of metabolic turnover of deoxyribonucleic acid or the occurrence of endo-



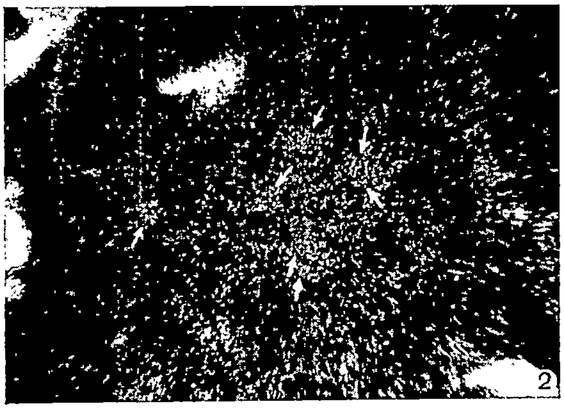


Fig. 1. Longitudinal section, shoot apex of *Pinus lambertiana* (phase-contrast image) showing cytological zonation, that is, zone I, terminal zone; zone II, peripheral zone; zone III, rib meristem. Arrows indicate nuclei which incorporated large amounts of phosphorus-32 into deoxyribonucleic acid

Fig. 2. Autoradiograph of same section (photographed with dark-field illumination). Centres of radioactivity, indicated by arrows, coincide with nuclei indicated in Fig. 1. Scattering of light, due to refractiveness of certain cells and/or damage to the photographic emulsion, is evident near the tip of the apex, in young leaves, and in developing pith cells, but does not represent radioactivity. (Both figures × 210)

mitotic reduplication. The very presence of these highly radioactive centres within the bounds of the terminal zone would indicate that these nuclei do divide since the alternative sequels to synthesis of deoxyribonucleic acid can very likely be ruled out. If the French workers were correct in their interpretation, the centres of high activity would be immediately below the line separating the terminal and peripheral zones, but not in the terminal zone.

Autoradiographs (not shown here) showing total nucleic acid synthesis (deoxyribonucleic acid plus ribonucleic acid) indicate a rather high level of activity which appears to have a relatively uniform distribution throughout the apex. However, it should be pointed out that owing to such complicating factors as 'background activity', which is more or less uniformly distributed in the emulsion, subtle differences of degree of activity as well as its total absence are difficult if not impossible to demonstrate by these means.

At the present stage of these investigations it would seem that the observations made here for *Pinus* would apply generally to the other species examined, which include *Glycine max*, *Chenopodium alba* and *Ginkgo biloba*. A more extensive report of these observations will be published later.

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Induced Apospory in Polypodiaceous Ferns

The induction of outgrowths of gametophytic tissue from the sporophyte in mosses has been accomplished many times since Pringsheim[1] first reported it. In the ferns, the aposporous production of fully sexual gametophytes from genetically normal sporophytes has been considered to occur less readily. Although various forms of apospory in a number of ferns have been reported by Goebel[2] and others, the only well-investigated example of its induction and consequences is in *Osmunda*, where apospory was induced by continued maltreatment and malnutrition of the sporeling[3].

Recent experiments have shown that apospory can be regularly induced in normal sporelings in at least two other species of fern, namely, *Thelypteris palustris* and *Pteridium aquilinum*. Sporelings were raised from gametophytes grown in pure culture from spores from wild populations of these ferns. The first or second leaves of the sporelings were detached when fully expanded and placed on sterile mineral – agar slopes, a small square of glass being used to press a portion of each lamina close to the medium. With only one exception (where the leaf died) in numerous experiments, filaments have grown out from the margin or surface of the leaf (Fig. 1). The filaments eventually gave rise to cordate gametophytes. In *Thelypteris* it was afterwards found that leaves up to at least the tenth continued to show this phenomenon.

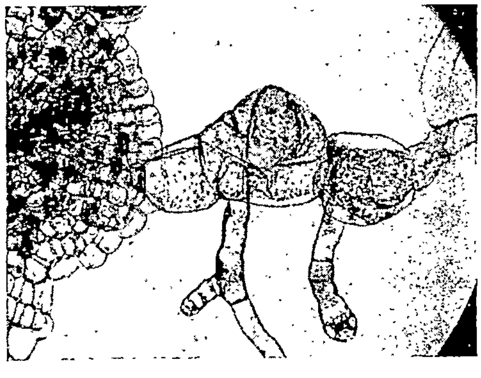

Fig. 1. *Pteridium aquilinum*. Filament growing out from marginal cell of the first leaf of a normal sporeling detached and placed on agar. (× 150)

It was considered possible that sporelings giving rise so readily to gametophytic tissue were abnormal, but no evidence could be found in support of this view. The sporelings arose after controlled fertilization and had every appearance of being produced by the normal sexual means. Furthermore, the development of the sporelings after the removal of the leaves for experimentation showed no peculiarities.

Additional evidence in favour of the normality of the intermediate sporelings was obtained by comparing the amount of deoxyribonucleic acid in the nuclei of the gametophytes produced aposporously with that in the nuclei of the original. Specimens of both sets of gametophytes were fixed, sectioned, and the sections stained simultaneously in Feulgen's reagent according to Partanen's schedule[4]. The intensity of the staining was measured with a scanning microspectrophotometer built by Deeley[5]. The results are shown in Fig. 2. As expected, the amounts of deoxyribonucleic acid in the nuclei of the two sets of gametophytes are in the ratio 2 : 1. Some estimates were also made of the deoxyribonucleic acid in the nuclei of a young crozier from one of the sporelings. Because of the harder cell walls, few nuclei in these sections could be satisfactorily flattened for scanning, but the results obtained fully support the normality of the sporeling.

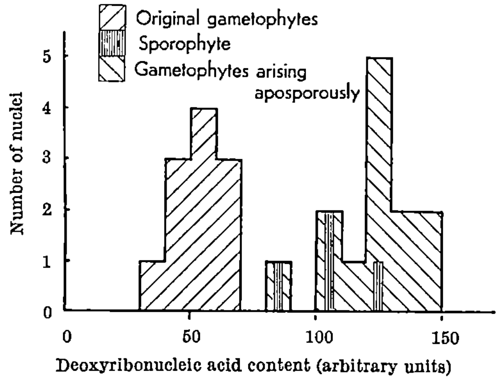

Fig. 2. *Thelypteris palustris.* Amounts of deoxyribonucleic acid in nuclei of normal gametophytes, a normal sporeling and gametophytes arising aposporously

It can be concluded, therefore, that by the technique reported here, outgrowths of gametophytic tissue can be obtained readily from the sporophytes of two species of polypodiaceous ferns without the intervention of meiosis. Gametophytes obtained in this way have produced sex organs, and sporelings raised from them are the subject of further study. There seems no reason why the technique should not be generally applicable in the ferns.

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Symptoms of Calcium and Phosphorus Deficiency in Oil Palm Seedlings

Previous attempts[1,2] to induce symptoms of calcium and phosphorus deficiency in oil palm seedlings grown in water-washed quartz sand have failed. Symptoms have now been induced by growing oil palm seedlings in quartz sand purified by treatment with hot 1 per cent sodium carbonate and hot, constant-boiling hydrochloric acid.

The experimental methods used were based on those recommended by Hewitt[3] for critical work on nutrient deficiencies. Quartz sand obtained from a local riverine deposit was substantially freed from clay and organic matter by digestion in a Kestner apparatus[3] for two successive 4-hr. periods followed by a third digestion for 3 hr. with hot, constant-boiling hydrochloric acid. Free acid was removed by leaching with de ionized water derived from mixed-bed ion-exchange columns. The specific conductivity of this water was $0{\cdot}3 \times 10^{-6}$ mho cm.$^{-1}$ at 27° C. Adsorbed hydrogen ions were displaced by leaching with $0{\cdot}02$ M magnesium nitrate until the pH of the effluent exceeded 5·5. In calcium- and phosphorus-deficient nutrient solutions, sodium was substituted for calcium and sulphate for phosphate respectively. Iron was supplied as iron-ethylenediamine tetraacetic acid at a concentration equivalent to 5 p.p.m. ferric iron. In all other respects the nutrient solutions employed were identical with those used at Long Ashton[3]. Seedlings which had been grown in soil for the first two months from germination were transplanted to pure sand in bitumen-lined glazed porcelain pots in late April, and symptoms first appeared during early August.

Phosphorus Deficiency. The first symptom of this disorder was a general reduction in growth and vigour as compared with the complete nutrient control treatment. The oldest leaves became dull and assumed a pale olive-green colour (Munsell Color Fan 2·5*GY* 5/5). As the severity of the deficiency increased emerging leaves became progressively more chlorotic (Munsell 2·5*GY* 6/8) and terminal necrosis appeared on the oldest leaves. Necrotic areas were in general dark brown but their colour was somewhat variable. Where the necrosis developed rapidly, affected tissues were light brown (Munsell 5*YR* 4/5–3/3), but more usually the necrotic areas became blackish-brown or purplish-brown in colour. No

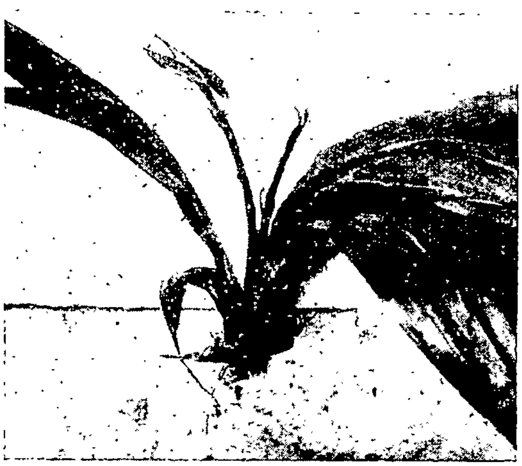

Fig. 1. A seedling deficient in calcium. The central leaves are malformed

obvious chlorotic band separated necrotic from healthy tissues when affected leaves were examined in reflected light. Examination in transmitted light revealed a pale band of tissue, with a water-soaked appearance, at the proximal limit of necrosis. This band was narrow, being about 2–3 mm. wide and yellow in colour (Munsell 10*Y* 6/7). These symptoms suggest that in phosphorus-deficient leaves collapse of cells occurs rather abruptly. Interveinal ochre spots (Munsell 7·5*Y* 6/7) were occasionally present near leaf margins but their significance is obscure. In phosphorus-deficient seedlings leaves are reduced in size and the plastochrone is increased.

Calcium Deficiency. The first characteristic symptom of this disorder was the appearance of a leaf which was abnormally short, narrow and rigid with prominent veins (Fig. 1). In slightly older leaves, which are normally bipinnate in form, one-half of the leaf blade was often narrower than the other with apical splitting and some terminal necrosis. As the deficiency became more severe, there was a progressive reduction in the area of emerging leaves ; this reduction exceeded 90 per cent in the leaves most malformed. Terminal necrosis became more severe and ultimately the leaves produced comprised merely the basal part of the petiole. Intermediate leaf shapes occurred in which the leaf blade was truncated and spatulate or strap-shaped with a slight apical indentation. No chlorosis was observed in association with the morphological changes described. Abnormal leaves were dark green (Munsell 5*GY* 4/3) and identical in colour with leaves of control plants receiving a complete nutrient solution.

These observations were made on a large experiment investigating macronutrient deficiency symptoms in seedling oil palms, and the results of this experiment will be published in greater detail elsewhere.

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A Revised Interpretation of the Causes of Loss of Crops of Cotton in the Drier Regions of Uganda

For many years *Lygus vosseleri* Popp. has been considered to be the major cotton pest in Uganda[1].

Recent work at Serere in eastern Uganda suggests that this may not be true of the drier areas. Analysis of a large insecticidal experiment using DDT showed that a high degree of control of 'spiny bollworm' (*Earias* spp., Lepidoptera, Noctuidae) was being obtained, as illustrated by the results from a flower bollworm count (Table 1).

Table 1

Applications of DDT	Damaged flowers	
5	43	*L.S.D.*
3	109	at 5 per cent $P > 0{\cdot}01$
1	172	62·6
Control	204	

Subsequent analysis of sheds damaged by bollworm (which can be shown to be mainly due to *Earias* spp.) from this and many previous experiments showed that control of *Earias* by DDT has been achieved over many years but had escaped notice due to a preoccupation with efforts to correlate increases of yield with *Lygus*.

It has been impossible to correlate the assessment of any form of damage by *Lygus* with subsequent increases in yield, but highly significant correlations are obtained with all measures of bollworm infestation.

Laboratory work has shown that *Earias* larvæ are capable of doing very severe damage to young cotton plants, removing many small fruiting points, 'tattering' leaves and boring into the growing points. In fact, at this stage of growth of the plants, *Earias* is not a true 'bollworm' but is a general feeder on fruiting points and growing points. The larvæ wander extensively over the plant and, at this stage, no single boll is large enough to sustain a larva through to maturity. It is suggested that this allows considerable pick-up of DDT, especially in the younger instars, resulting in the observed control. So far as can be ascertained, this would appear to be the first recorded case of economic control of *Earias* spp. with DDT on cotton.

The spraying practice now being advised for peasant cotton[2], originally directed against *Lygus* which is probably not responsible for the bulk of the damage, is giving adequate protection against *Earias*.

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Chromosome Aberrations in Calcium-deficient *Tradescantia* produced by Irradiation

The lack of calcium in *Tradescantia* microspores and in barley seeds has been demonstrated to increase the frequency of X-ray-induced chromosome aberrations above similarly irradiated material grown with optimal calcium[1,2]. Mechanisms by which the lack of calcium could cause such an effect have been discussed[1]. It is necessary to distinguish between two important alternatives : (1) does the absence of calcium confer a unique instability on chromosomes as observed by increased breakage, or (2) is the mechanism of increasing breakage more indirect ? A likely possibility in the latter category could involve low or high viscosity of the nucleoplasm. Calcium, potassium, sodium, magnesium and manganese are reported to influence viscosity to various degrees[3]. If the increased chromosome sensitivity to radiation acts by a change in viscosity, then metals other than calcium should have similar effects. Previously, magnesium and manganese have been shown to have no effect on modifying the frequency of chromosome aberrations by X-rays[1]. Sodium is not usually an essential element in plants. Potassium is considered here in experiments with *Tradescantia*.

In an extensive series of experiments with various plant species Lundegårdh and others[4] have demonstrated a reciprocal relationship between potassium and calcium. As a rule in nutrient culture when potassium concentration is low and calcium is optimal, then more calcium accumulates in leaves and flowers than potassium as determined by flame photometry. High potassium in the nutrient solutions greatly reduces the movement and accumulation of calcium above the roots. In the latter instance potassium accumulates in the upper part of plants in high concentrations.

The methods have been described by which inflorescences of *Tradescantia paludosa* were cultured and irradiated[1]. As seen in Table 1, limiting potassium in water culture has little or no effect on the frequency of chromosome interchanges. At the lowest concentration of potassium (2·4 p.p.m.) interstitial deletions were significantly lower than controls. When calcium was limiting, both interchanges and interstitial deletions were 40 per cent higher than controls. Thus, calcium seems to be the key metal effecting radiosensitivity.

Nilan and Phillips[2] have recently reported experiments with barley seeds collected from plants grown on low calcium. Twice as many chromosome aberrations were produced in X-rayed seeds lacking calcium as in X-rayed seeds with optimal calcium. There were no differences in aberration frequency between the two levels of calcium when thermal neutrons were employed. These latter results are expected since proton and alpha tracks can break a chromosome whether it is labile or not. *Tradescantia* microspores at two levels of calcium were treated with sparsely ionizing gamma-rays. In Table 2 the differences between treatments are of the magnitude produced by 250 kVp. X-rays (Tables 1 and 3). Hard X-rays and gamma-rays have similar properties in respect to their ion densities[5]. A more labile chromosome would be expected to exhibit a higher sensitivity to these sparsely ionizing radiations.

Factors which modify radiosensitivity (for example, cysteine and cysteamine[6], carbon dioxide[7], carbon monoxide[8] and potassium cyanide[9]) are almost always dependent upon the presence of oxygen during irradiation. In the following experiment pre-purified nitrogen was used to X-ray inflorescences in absence of oxygen. A special 'Lucite' chamber was employed. Three evacuations and three nitrogen flushings were made before irradiation. From Table 3 we see that cells irradiated in nitrogen have about the same increase in sensitivity as cells treated in air. Apparently the influence of limiting calcium on chromosome breakability is independent of oxygen.

Table 1. A DOSE OF 400 R. OF 250 KVP. X-RAYS WAS GIVEN AT 100 R. PER MINUTE WITH 1 MM. ALUMINIUM AS FILTRATION

Treatment		Interchanges		Interstitial deletions		Total cells
	p.p.m.	No.	Per cell	No.	Per cell	
Control	250 Ca++ 195 K+	394	0·71	365	0·66	552
—K	4·9 K+ 250 Ca++	398	0·80*	326	0·66*	497
—K	2·4 K+ 250 Ca++	421	0·68*	330	0·53†	620
—Ca	2·1 Ca++ 195 K+	190	1·02‡	185	1·00‡	186

* Not significantly different from controls, $P > 0·05$ by χ^2 test.
† Significantly different, $P < 0·01$.
‡ Significantly different, $P < 0·001$.

Table 2. 400 R. of GAMMA-RAYS FROM COBALT-60 GIVEN AT 2,400 r. PER MINUTE

Treatment		Interchanges		Interstitial deletions		Total cells
	p.p.m. Ca++	No.	Per cell	No.	Per cell	
Control	250	285	0·71	310	0·78	400
—Ca	6·2	183	0·72*	243	0·96*	254
—Ca	4·2	465	0·74*	698	1·10†	632

* Not significantly different from controls, $P > 0·05$.
† Significantly different, $P < 0·001$.

Table 3. THE 250 KVP. X-RAYS WERE GIVEN AT 5(NUTE
WITH 1 MM. COPPER AND 1 MM. ALUMINIUM A: ON

Treatment			Interchanges		Ir		Total cells
		p.p.m. Ca++	No.	Per cell		cell	
1,000 r.	Control	250	750	1·13		1·42	663
in	—Ca	6·2	467	1·16*		1·97†	402
nitrogen	—Ca	4·2	705	1·38		1·82†	511
400 r.	Control	250	417	0·64		0·64	652
in air	—Ca	6·2	231	0·71*		1·05†	324
	—Ca	4·2	261	0·71*	258	0·70*	369

* Not significantly different from control by χ^2 test, $P > 0·05$.
† Significantly different from controls, $P < 0·001$.

The results are compatible with the general hypothesis that chromosomes are inherently more sensitive to breakage at reduced levels of calcium. The increased radiosensitivity appears either in the presence or absence of oxygen. The evidence indicates that lowering the calcium concentration increases the sensitivity to radiation by raising the probability of a sparse track breaking a chromosome. Presumably fewer ionizations can cause a break.

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Use of Artificially Liberated Larvæ in Experiments on the Setting Behaviour of *Spirorbis*

DURING a study of the systematics of the Spirorbinae (Serpulidae), it became clear that several forms are found characteristically on specific substrata. Whereas *Spirorbis borealis* Daudin occurs most abundantly on the brown alga *Fucus serratus*, *Spirorbis tridentatus* Levinsen (usually regarded as an ecophenotype of *Spirorbis borealis*[1]) is found only on stones and shells in dimly lit places. Another closely related form, which appears to be a distinct species previously confused with juvenile *S. borealis*, has

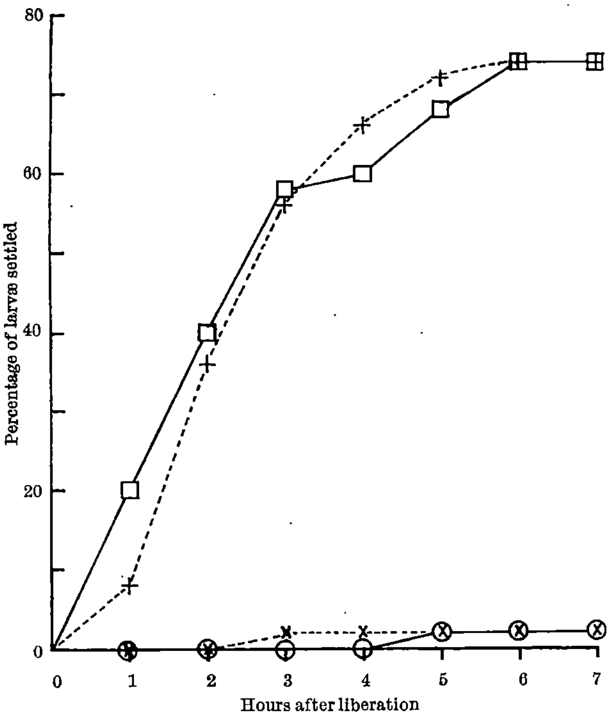

Fig. 1. Settlement of naturally and artificially liberated larvæ of *Spirorbis borealis* on *Fucus serratus* and *Corallina officinalis*. Larvæ settled on *Fucus*: □, naturally liberated; +, artificially liberated. Larvæ settled on *Corallina*: ○, naturally liberated; ×, artificially liberated

been found in the Swansea area only upon the red alga *Corallina officinalis*. Evidently it was desirable to find by experiment whether the larvæ of these forms choose their characteristic substrata.

Spirorbis borealis readily liberates larvæ in the laboratory[2,3]; but the other two forms referred to above do not. Their larvæ could be obtained in large numbers only by breaking the parents' tube and tearing up the chains of advanced embryos that were revealed. Many then hatched or were forced out of their egg capsules and swam towards the light. These larvæ seemed normal in appearance and behaviour. Before using them for experiments, however, larvæ were obtained in a similar manner from *S. borealis*. It was then possible to test the artificially liberated larvæ of this species against larvæ liberated naturally by their parents to see whether they were equally capable of metamorphosis and equally discriminating in their choice of a substratum.

In two parallel series of experiments, naturally and artificially liberated larvæ, in batches of about 25, were put into crystallizing dishes, each containing 100 ml. of sea water and a piece of *Fucus serratus*. After 24 hr., the numbers settled and metamorphosed were 355 out of 455 naturally liberated larvæ (78 per cent) and 229 out of 325 artificially liberated larvæ (70 per cent). The difference is not significant. The percentages are similar to that previously observed when larvæ of this species were presented with bare *Fucus serratus*[4].

In similar experiments, the percentages of larvæ settled were recorded after every hour. Those which had been artificially liberated settled just as early as the others (Fig. 1, upper curves). In parallel experiments pieces of *Corallina officinalis* were used instead of *Fucus* but few larvæ settled upon this alga (Fig. 1, lower curves).

In further experiments larvæ were offered a choice between pieces of *Fucus vesiculosus* and *Corallina officinalis* presented to them in the same dish. It was observed after 24 hr. that out of 200 artificially liberated larvæ, 142 had settled on *Fucus* and none on *Corallina*, whereas out of 200 naturally liberated larvæ 146 had settled on *Fucus* and 5 on *Corallina*.

It therefore appears that artificially liberated larvæ which are capable of swimming are as viable and discriminating in their choice of a substratum as naturally liberated larvæ. It will therefore be possible to use artificially liberated larvæ in experiments on the setting behaviour of other species of *Spirorbis*, particularly of the form which occurs so abundantly on *Corallina*. It seems unlikely that this form on *Corallina* is a young form of *S. borealis* since these experiments show that the larvæ of *S. borealis* do not settle readily on *Corallina*.

Similar methods of obtaining what might be regarded as prematurely liberated larvæ may be useful to workers engaged in anti-fouling research. It seems generally true that the ages at which crises in development occur are not fixed rigidly. Metamorphosis of a variety of planktonic larvæ can be postponed if they fail to find a suitable substratum[5,6]. Barnacle embryos may be retained as embryos by their parents for considerable periods, if there is little food available in the surrounding water[7-9].

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Flash Lighting for Egg Production

The use of artificial lighting to extend day-length to 13–14 hr. is well established in commercial poultry-keeping as a means of stimulating the production of eggs in winter. Weber[1] claimed that similar increases in yield could be obtained by a 'shock-lighting' technique in which two 20-sec. flashes of high-intensity light, administered at 4.00 and 4.45 a.m., were the sole additions to natural winter daylight. Over the past seven years a series of experiments investigating the nature of the response to flash lighting has been carried out at Reading with the aid of funds provided by the Agricultural Research Council, and with the co-operation of the Electrical Research Association. These have confirmed that, although Weber's regime does not give the best results, pullets can be stimulated to high production of eggs by a variety of flash-lighting treatments.

It seemed at one time that flashes of light were quite as effective as normal extended lighting so long as they supplied the same total quantity of illumination—16 lumen hr./ft.^{2}/day—in addition to the natural daylight available. In the winter of 1956–57 a series of treatments, all providing this

Table 1. Flash Lighting Experiment: December 1956—March 1957

Treatment No.*	Wattage of lamps	No. of flashes	Duration of each flash (sec.)	Time of first flash	Interval between flashes	Egg production (eggs/bird/day)
1	1,500	3	20	3.00 a.m.	1 hr.	0·824
2	1,000	5	20	,,	20 min.	0·821
3	750	7	20	,,	15 min.	0·819
4	500	10	20	,,	15 min.	0·818
5	300	18	20	,,	5 min.	0·820
6	1,500	10	6	,,	15 min.	0·804
7	1,000	10	10	,,	,,	0·819
8	750	10	14	,,	,,	0·821
9	500	10	20	,,	,,	0·817
10	300	10	35	,,	,,	0·818
11	60	2	2 hours	(5–7 a.m. : 5–7 p.m.)		0·821
12	—		(Control—winter daylight only)			0·767

* Treatments 1–11 all provided 16 lumen hr./ft.^{2}/day of illumination in addition to daylight from 7.0 a.m. to 5.0 p.m.

Table 2. Flash Lighting Experiment: September 1957—March 1958

Treatment No.	Wattage of lamps	No. of flashes	Duration of each flash (sec.)	Time of first flash	Interval between flashes	Light applied (lumen hr./ft.^{2}/day)	Egg production (eggs/bird/day)
1	—	(Control—winter daylight only)				—	0·549
2	500	10	20	3.00 a.m.	15 min.	16	0·631*
3	1,500	3	20	1½ hr. before sunrise	15 min.	16	0·510
4	300	4–18†	10	14 hr. before sunrise	20 min.	2–8*	0·610*

* Treatments 2 and 4 significantly better than 1 and 3, $P < 0{\cdot}05$.
† Number of flashes varied to fill the interval between (sunset—14 hr.) and sunrise.

quantity of additional light, but varying widely in the intensity, number and duration of flashes, were tested and gave very uniform results (Table 1). Despite this uniformity, it remained difficult to reconcile the hypothesis of an 'optimum quantity' of light with any satisfactory physiological explanation, especially since the additional illumination is only a fractional increase on the relatively large, and very variable, amount of light provided by a winter day.

Farner *et al.*[2] (studying testicular development in sparrows) have postulated a light-sensitive mechanism capable of activation almost immediately upon the onset of lighting and remaining active for some time during the ensuing darkness. A similar mechanism, affecting the activity (rather than the growth) of the fowl's ovary, would allow an alternative explanation of the flash-lighting effect. If activation commences with a first flash at 3.0 a.m. and is maintained by subsequent flashes until daybreak, then the bird could be said to be 'illuminated' throughout this period. Thus the critical condition for the success of flash-lighting (for laying hens) would be an interval of 13–14 hr. between the first flash and sunset. A recent trial (see Table 2) has shown that the time of application of light can be altered so that it is no longer an effective stimulus (treatment 3); and that a much smaller quantity of light, applied at the right time, is sufficient to produce maximum response (treatment 4). The fact that Weber, working at Berne in Switzerland, found flash lighting from 4.0 a.m. to be satisfactory, whereas at Reading we have demonstrated that it is necessary to start at 3.0 a.m. to achieve results comparable with extended lighting, may be accounted for by the difference in the times of winter sunset at the two latitudes.

We can now argue that flash lighting does not differ in principle from the familiar techniques of poultry-house lighting. Although a satisfactory physiological explanation of the way in which light influences the rate of ovulation is no nearer, it is now possible to include the flash lighting of poultry as yet another aspect of photoperiodism in animals.

To define minimum standards for intensity, duration and number of flashes required to stimulate maximum production of eggs, allowing for possible interactions, would require an extensive series of trials. However, the assumption that 'high-intensity' illumination is required is probably false and a considerably smaller total quantity of light than was used in treatment 4 (shown in Table 2) might well suffice. Since none of the experiments at Reading has shown flash lighting to be superior to the standard 14-hr. day, and since the equipment needed for flashing is rather elaborate and the saving in cost of electricity is unimportant, there is little reason to recommend the use of this technique in practice. In special circumstances where it is necessary to stimulate egg production without encouraging other forms of activity in the bird, flash lighting may be of value.

It has long been assumed that maximum production of eggs in the fowl is attained under conditions of constant day-length, although Whetham[3] questioned this assumption more than twenty-five years ago and King[4] has recently published some evidence suggesting that continuously increasing day-length may be preferable. While we have recently shown[5] that onset of sexual maturity in the fowl is affected by changes in day-length and not by the absolute level of day-length, the problem of the light regime needed to elicit maximum rate of egg laying in the fowl requires separate intensive study. It is not necessarily true, as has sometimes been assumed, that conditions which are most favourable for bringing the gonads into a reproductive state are also the most favourable for maintaining a short interval between successive ovulations.

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Occurrence of *Microsporum gypseum*, *Keratinomyces ajelloi* and *Trichophyton terrestre* in Some British Soils

In recent years many attempts have been made to confirm the belief that dermatophytes have a saprophytic existence in the soil. These investigations have disclosed the widespread occurrence of the pathogenic species *Microsporum gypseum* (Bodin) Brumpt[1-6] and the existence of the saprophytes *Keratinomyces ajelloi* Vanbreuseghem[2,5-7] and *Trichophyton terrestre* Durie and Frey[8].

A preliminary examination of some British soils has been made using the method developed by Vanbreuseghem[9]. The samples were collected by scraping into sterile boiling-tubes. They were then placed in Petri dishes and moistened with sterile distilled water. Short strands of autoclaved human hair were placed on the soil surface and the plates were left at room temperature (approximately 20–22° C.). Visible mycelial growth appeared on the hair in two to four weeks. Small pieces of mycelium and infected hair were transferred to plates of malt agar containing cycloheximide ('Actidione') 0·5 mgm./ml., penicillin 40 units/ml., streptomycin 40 units/ml. and potassium tellurite 0·36 mgm./ml.

The soils were collected from areas in and around Bath, Somerset, where clay on limestone predominates. Thirty samples were examined; of these, seven came from farmland and eleven were garden soils, the remaining twelve being from woodland, parkland, riverside and roadside banks and river gravel.

Results are summarized in Table 1.

Table 1

	Farm	Garden	Others
K. ajelloi only	1	9	1
K. ajelloi + *M. gypseum*	1	1	—
K. ajelloi + *T. terrestre*	3	—	2
Negative for these species	2	1	9

One of the farm soils which yielded *K. ajelloi* and *T. terrestre* contained cow hairs and another contained feathers. The conidia of these species were seen on direct microscopical examination of the disintegrating feathers in the latter sample.

Various other keratinophilic fungi which have not yet been identified were also encountered both in the presence, and in two cases in the absence, of the three known species. The ten soils from which no keratinophilic fungi were isolated included a mole-hill in a pasture, a recently ploughed field, a roadside bank and all the seven woodland soils examined.

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Freemartins in Sheep

With cattle twins of opposite sex the female is in almost all cases infertile and shows varying degrees of masculinity, both in behaviour and in the morphology of the reproductive tract. Such females are known as freemartins. Swett *et al.*[1] consider that the freemartin condition is due to irreversible modification of the female by masculinizing secretions from the male fœtus. It is possible for any such secretions to pass between the two fœtuses as it has been known for some time that the bloods of twin calves are able to mix through anastomoses in the placental vessels[2].

Owen[3] and Owen *et al.*[4] have reported that most dizygotic twin calves are red blood-cell chimæras. They are born with, and often retain throughout life, red cells of dual origin. The same authors argued that since the life of red cells is short, red-cell precursors must be exchanged between the twins via the placental anastomoses during fœtal life and these precursors must establish themselves in the tissues of the opposite twin. It has been shown that the majority of dizygotic twin calves are tolerant to each other's tissues[5]. They will accept homografts of each other's skin, whereas grafts exchanged between calves of the same parentage but born at different times are rapidly rejected.

In a recent study in which attempts were made to induce a state of acquired tolerance in sheep, we used the fate of skin homografts as a criterion to determine if tolerance had been established. In the sheep, skin homografts are normally rejected and die within 10 days of grafting, whereas autografts are accepted by the host[6]. In the course of this study grafts were exchanged between sheep twins of opposite sex; in all, five sets of such twins were involved. Four of the five sets showed normal homograft reactions, the skin dying within 10 days, whereas the homografts on the remaining pair behaved as autografts. At the time of writing these surviving grafts are 245 days old, and both appear quite healthy, each being covered by an excellent growth of wool. The female of this pair shows abnormal development of the vulva and clitoris (Fig. 1), and although now more than two years old has never shown any signs of œstrus. She does in fact appear to be a freemartin.

Freemartins in sheep have only been reported sporadically[7,8]. The observations reported above provide further evidence for the occurrence of freemartins in

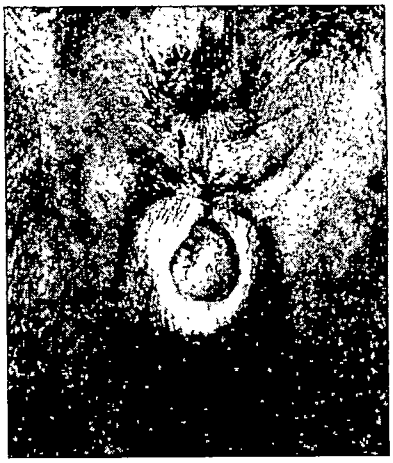

Fig. 1. Enlarged vulva and clitoris of female twin

sheep, and they suggest that a state of tissue tolerance may exist between the freemartin and her male twin.

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Automatic Subdivision of Associated Populations

Consideration has been given in the past to the factorial analysis of qualitative data[1], including that particular form in which the attributes (presence-or-absence, yes-or-no) can take only the values 0 or 1, so that the correlation matrix is obtained from a set of 2×2 contingency tables[2]. Little attention has been paid to the valuable information to be obtained from the subdivision of populations of this latter type. Goodall[3], working with vegetation, pointed out that such populations are divisible into "homogeneous" groups, in which all associations are either indeterminate (a given attribute being 0 or 1 in all members of the group) or below a predetermined significance-level. Unfortunately, he elected to divide by reference to a criterion which is inefficient, and which tends to produce final groups capable of ambiguous recombination.

The problem is to find the attribute which, at each stage of subdivision, is most likely to reduce the residual associations to their lowest possible level. At first sight, an attractive solution would appear to be to divide on the attribute with the highest loading, irrespective of sign, on the first principal axis of the correlation matrix. However, although finding this presents no difficulty on an electronic computer, it involves not only calculating but also storing all the elements of the matrix, thus seriously reducing the space available for the basic data (that is, the specified individuals). A similar objection applies to the corresponding element of the first centroid axis. Furthermore, it is by no means certain that the resulting division is the best for all purposes. As has been pointed out elsewhere in connexion with the ecological application of the problem[4], Goodall's definition of a "homogeneous group" depends ultimately on a significance test, the simplest of which for such purposes is the calculation of χ^2 with Yates' correction. If this criterion is in fact used, a preferable solution is to divide by reference, not to the correlation matrix, but to the corresponding contingency matrix. The correlation coefficients (r) can then all be taken with the positive sign, and the attribute with the highest $\Sigma\ |r|$ will necessarily be the attribute with the highest loading on the first centroid axis of the contingency matrix. (We prefer to use $|r|$ rather than r^2, the mean-square contingency itself, since it provides a closer analogy with factorial analysis; experience suggests that this does not discernibly reduce the efficiency of subdivision.) Since the $|r|$ values can be summed as they are obtained, it is necessary to provide only as many storage locations as there are attributes. Except for very large projects, ample space is thus available for both programme and data, and the subdivision can be made fully automatic.

We have therefore prepared, for the Ferranti 'Pegasus' computer, a programme which, from the specifications of all the individuals concerned, will carry out completely automatic subdivision into groups homogeneous at the $P = 0{\cdot}05$ level of significance. The highest χ^2 encountered during the examination of any group is printed out, thus permitting cross-comparison of all intermediate groups; and provision is made for disregarding any attributes which it is desired to exclude from the analysis. The programme exists in two alternative forms: the first will process up to 3,360 individuals specified by not more than 38 attributes, the second up to 1,680 individuals specified by not more than 76 attributes.

The resulting information may be used in several ways. Most important is the study of the structure of the homogeneous groups themselves, with particular reference to the disposition of those attributes not specifically used for subdivision. Secondly, as these latter attributes are inherently likely to be of importance in any subsequent factorial analysis, the fact that they are already known may well facilitate decisions on the placing of hyperplanes; in fact, we suspect that in some cases sufficient information may be obtained from the subdivision to render the far more laborious factorial analysis unnecessary. Lastly, if, as in ecological work, the individuals are of known distribution in space, the groups can be plotted on a map.

W. T. Williams
Botany Department,

G. N. Lance
Computation Laboratory,
University of Southampton.
Oct. 14.

[1] Burt, C., *Brit. J. Psychol.* (Stat. Sect.), **3**, 166 (1950).
[2] Slater, P., *J. Roy. Stat. Soc.* (Supp.), **9**, 114 (1947).
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Salt Excretion in Marine Birds

In connexion with recent research on salt excretion in marine birds[1,2] the following observation which I made some twenty-five years ago may be of interest. While cruising in a yacht far from land in the northern North Sea, I often used to watch lesser black-backed gulls as they soared above the ship or were perched on the mast head. I was very puzzled to account for a regular rain of drops of water which each bird shook at intervals from the tip of its beak. This was evidently salt excretion in action, and I know of no similar published account.

F. S. Russell

The Laboratory, Citadel Hill,
Plymouth.

[1] Schmidt-Nielsen, Knut, and Sladen, W. J. L., *Nature*, **181**, 1217 (1958).
[2] Schmidt-Nielsen, Knut, and Fange, Ragnar, *Auk*, **75**, 282 (1958).

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Psychologist (male, with a first- or second-class honours degree with psychology as the main subject or equivalent qualification) at the Ministry of Supply Clothing and Stores Experimental Establishment, Farnborough, Hants, to work in the Applied Psychology Section on the design of military equipment aiming at greatest efficiency, comfort and safety in its operation—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. G.409/8A (December 23).

Scientist (Mathematician, Physicist or Engineer) (with at least a second-class honours degree or equivalent in an appropriate subject, and suitable research experience) at Dounreay Experimental Reactor Establishment, to lead a team responsible for mathematical physics calculations in connexion with the Fast Reactor and laboratory investigations of associated problems—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire, quoting Ref. 2797/T (December 29).

Lecturer (Veterinary Surgeon) in Veterinary Pathology—The Registrar, The University, Liverpool (December 30).

Library Assistant (Special Grade) (honours graduate, preferably with a diploma in librarianship and some previous library experience) —The Secretary of University Court, The University, Glasgow (December 31).

Chair of Nuclear Engineering—The Registrar, The University, Manchester 13 (January 1).

Demonstrators in Biochemistry and Nutrition and/or Physiology in the Faculty of Rural Science—The Registrar, University of New England, Armidale, New South Wales, Australia (January 1).

Secretary to the British Trust for Ornithology with offices at Oxford, for duties which include the supervision of field investigations, financial and office administration, correspondence with membership, attendance and speaking at meetings, and public relations—The Honorary Secretary, R. K. Cornwallis, British Trust for Ornithology, Bleasby Grange, Legsby, Market Rasen, Lincolnshire (January 1).

Assistant in Research (with an appropriate honours degree and preferably an interest in animal genetics) in Animal Physiology—The University, Downing Street, Cambridge (January 7).

Senior Technician (with experience in the maintenance of colonies of animals) in the Departments of Biological Sciences and Pharmacy, to take charge of the animal house—The Registrar, Bradford Institute of Technology, Bradford 7 (January 7).

Assistant Lecturer or Lecturer (with an honours degree in architecture and special knowledge of the application of scientific research to building construction) in the Department of Building Science—The Registrar, The University, Liverpool (January 10).

Chair of Geology—The Secretary, The University, Exeter (January 17).

Senior Lecturer or Lecturer (with registrable medical qualifications) in Anatomy at the University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (January 26).

Assistant Lecturer in Applied Mathematics—The Secretary, The Queen's University, Belfast (January 30).

Lecturers (2) (preferably, but not necessarily, experience of research work in experimental or theoretical nuclear physics) in the Department of Physics—The Registrar, The University, Liverpool (January 31).

I.C.I. Research Fellows in Biochemistry, Chemistry, Engineering, Pharmacology, Physics, Chemical Technology or Chemical Engineering—The Secretary, The University, Edinburgh (February 16).

I.C.I. Research Fellows in Chemistry, Biochemistry, Physics, Engineering, Chemotherapy and related subjects—The Secretary, Academic Council, The Queen's University, Belfast (March 1).

Assistant, Grade B (with a good degree) at the Municipal College of Technology and Commerce, Bournemouth, to teach mathematics principally to G.C.E. advanced level—Chief Education Officer, Town Hall, Bournemouth.

Assistant Biochemist (B.Sc.) in the Fife District Laboratory, Windygates—The Medical Superintendent, East Fife Hospitals Board of Management, 243A High Street, Kirkcaldy.

Associate Professor (with experience in both teaching and research) of Electrical Engineering in the School of Engineering, Carleton University, Ottawa, Ontario, Canada—Dr. J. G. Malloch, Scientific Liaison Officer, National Research Council of Canada, Africa House, Kingsway, London, W.C.2.

Biochemist (with an honours degree in chemistry or biochemistry and preferably with experience of biochemical research), to carry out research on metabolic diseases of farm animals—The Secretary, Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh 9.

Curator (between the ages of 25 and 35, at least B.Sc. zoology, preferably with entomological leanings) of the Nyasaland Museum, to build up a museum exhibition from available collections and from collections to be made—The Secretary, Museum Board of Trustees, The Secretariat, Zomba, Nyasaland.

Ecologist (with a good honours degree in botany and at least two years postgraduate experience or training in ecological survey methods including aerial photograph interpretation) in the Ministry of Agriculture, Northern Region of Nigeria, to be responsible for all vegetation aspects of the ecological, soil and land-use surveys currently being undertaken by the Northern Region Ministry of Agriculture—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/408/012.

Physicist or Chemical Engineer (with a good honours degree and preferably some experience of research) in the Blast Furnace Laboratory, Imperial College of Science and Technology, London, S.W.7, for laboratory and theoretical work on heat transfer and combustion problems—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "H.T.1".

Scientific Officer (preferably Botanist/Physiologist) in the Pomology (Horticultural Botany) Department, for work mainly on selective weed control; and a Librarian—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee.

Statistician (graduate, with suitable qualifications and experience, preferably including field trials)—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

Technician (preferably with previous experience) in the Chemistry Laboratories—The Secretary, Royal Holloway College (University of London), Englefield Green, Surrey.

Technician (with experience in chemistry, and preferably some knowledge of glass-blowing) in the Biochemistry and Chemistry Department—The Secretary, Guy's Hospital Medical School, London Bridge, London, S.E.1.

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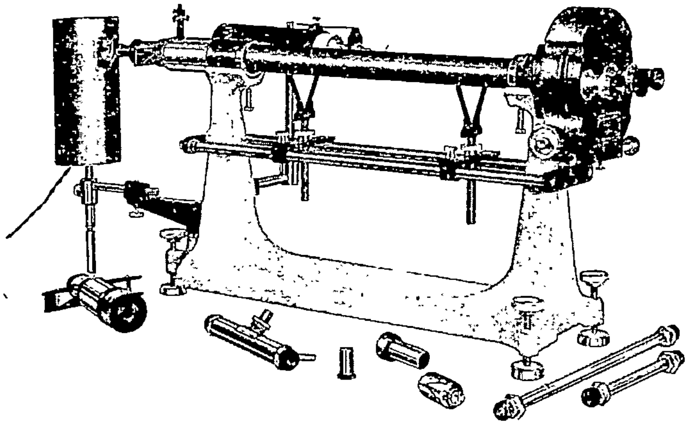

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ALLOCATION OF FUNDS FOR RESEARCH IN BRITAIN

ONE of the most important chapters in the recent report from the University Grants Committee on "University Development 1952–57" is that in which the Committee discusses the question of scientific research. After considering the balance between research and teaching, clear warning is given that, even if a reasonable proportion is maintained between them, balanced development of the work of the universities will only be ensured by unceasing vigilance that sponsored research and other outside support is not accepted on terms inconsistent with that development. The report then discusses in some detail the respective functions of the University Grants Committee and the research councils. This passage alone raised the whole question of the effective organization and management of the scientific effort of Britain within the pattern of values that characterizes our society and the peculiar requirements of science. It is clear that the University Grants Committee is deeply concerned with both the manner in which new lines of scientific work should be administered and the sources from which they should be financed.

The importance of this particular aspect of the subject has been emphasized recently by the criticisms of the Committee of Public Accounts of the Jodrell Bank radio telescope project and the situation which has led the University of Manchester to launch an appeal to raise the £150,000 still required to meet the costs. More generally, it was indicated by Prof. A. C. B. Lovell in the fourth of his Reith Lectures, on November 30, when he discussed formally the issues involved in the support of financial research by the State. Prof. Lovell made no direct reference to the Jodrell Bank situation, or to the proposal for a British programme of specialized space research which is understood to have been recommended by the Royal Society Conference on Space Research. It was rather the magnitude of the expenditure required to support such lines of research and the sacrifices inevitably demanded elsewhere with which he was concerned. Sacrifices may in fact well be demanded, if not in real standards of living, at least in some of the non-essentials that are too lightly taken for granted, without regard to the continuing scientific and technical effort through which alone they have been achieved.

Prof. Lovell did not stray into the field of politics or even of sociology; it was only obliquely that he indicated that a choice may have to be made between defence and security as at present conceived and the continued existence of mankind. Granted, however, that the transfer of effort and resources from the demands of defence to the constructive purposes of peace would release more than sufficient for the prospective needs of civil research and development, no statesman of any political party could contemplate such a step or propose the sacrifices that would be entailed or required by alternative measures without himself first very clearly apprehending what is involved from the point of view of science and technology, and then taking the most positive and energetic steps to prepare the electorate for whatever changes and sacrifices are required. As one first condition of any such attempt, both political parties must cease all attempts to make party capital out of the situation.

There is thus pre-supposed a very considerable campaign of education at high levels before we can hope to see any Government proposals allocating resources for scientific and technological development on the scale now desirable. Parsimony is not to be cured quickly, and there is always the over-riding problem of balance. Even a programme of £15 million a year over four years for space research is not to be approved lightly and without regard to possible repercussions on other fields of scientific and technological research; and once a programme has been approved, there is continuing need for public understanding and support. Sir Eric Ashby rightly remarked in his recent book "Technology and the Academics": "That a university should interpret itself to its patrons and explain its need for autonomy is . . . a necessary feature of its adaptation to the scientific revolution", and the comment is equally relevant to the independent research institutions and the research councils.

Prof. Lovell clearly recognizes this need for exposition and interpretation, and, although the administrative aspects were outside his survey, he just touched on the conditions of freedom and independence in which alone scientific research can flourish and which it should be a prime objective of administrative organization and policy to foster and preserve. Long-term dangers are inseparable from the support of fundamental scientific research by the State on a large scale, and the delicate and perilous situation which faces university administrators in Britain is without precedent. Failure to absorb these great new scientific projects into a framework where the traditional university freedom of inquiry can flourish would, he believes, be fraught with grave dangers to scholarship and scientific education.

All this is very clearly in the mind of the University Grants Committee, and in this perspective the actual balance of effort between teaching and research appears to be a secondary issue. In any event, the Committee rejects the view that the balance could be determined precisely, or even that the cost of research in universities can be estimated closely. It suggests that the cost of scientific research in universities in science, technology, medicine and agriculture was about £16 million in 1955–56 and probably £20 million in 1957–58, part of the difference being due to an increase in academic salaries. Of this amount, £2,307,000 in 1955–56 was received for research sponsored by bodies outside the universities,

£1,246,000 coming from the research councils and other Government departments.

In 1956–57 these figures rose to £2,683,000 and £1,377,000, respectively, and although they do not cover all the expenditure which could be apportioned to research if the whole of the recurrent expenditure of the universities were divided between the various activities carried out in them, the University Grants Committee appears to be justified in its view that government departments and agencies are not making excessive demands on universities in the matter of sponsored research. Research which is financed by the Council for Scientific and Industrial Research, the Medical Research Council, the Agricultural Research Council and the Nature Conservancy is generally free from these dangers, since it follows lines which are selected predominantly by the university research workers themselves ; hence the Committee is disinclined to extend its own responsibilities for financing academic research.

Without some clarification of this point, however, the views of the University Grants Committee may not be generally shared. The re-organization now proceeding under the Council for Scientific and Industrial Research is being closely watched, and it is too early to feel any real assurance that such research will be supported more generously in the future, or even that the Council is the most appropriate means through which State grants should be made for fundamental research : the Jodrell Bank episode alone would suggest reserve on that point. Again, it cannot be suggested that support of the Nature Conservancy has been other than meagre, amounting almost to starvation where research is concerned.

Nevertheless, the University Grants Committee emphasizes a vital point in directing attention to the desirability of research workers in universities (or indeed in independent institutions anywhere) being able to obtain support from more than one source for lines of research which they wish to pursue. This is particularly true in respect of newly emerging lines of research, and though a Government source of finance cannot be expected to provide the same continuity or even support on the same scale at the start for the growing points as the independent foundation, there is sound reason for public support, in this way providing funds alternative to general university income. The problem is rather as to the means by which such support is most appropriately and effectively made available.

On this point, the University Grants Committee lays down very clearly its reasons for declining to be the source of earmarked funds for new lines of research. First, it insists that if university autonomy is to be a reality, it must continue to minimize its intervention in the allocation of funds within universities, which already receive 70 per cent of their income from the Committee. Secondly, it stresses the value of direct relations between a body supporting particular lines of research and the individual research worker and university department, as is possible with the research councils and the Royal Society. Again, the membership of the research councils and their committees, together with that of the Government Grant Boards of the Royal Society, includes the most experienced workers in the respective fields which they cover. Quite apart from the fact that the University Grants Committee, while exercising its present functions, could not give the same expert scrutiny and assessment to research projects without developing an unwieldy organization, the Committee makes the vital point that it is undesirable that such a single governmental colossus should bestride the whole university world. Finally, the universities have no monopoly of research, and it is necessary that any agency established to stimulate research in any field should be in a position to survey all the research in that field, decide whether any particular line of research is best pursued in a university or in some other establishment, and maintain due contact between university and other research.

This value of diversity of sources of finance is so great as to outweigh the possible danger of overlapping ; nor is it likely that any serious gaps in the field of science will be left uncovered between the research councils and the Royal Society. Provided that reasonable funds are made available to them, the informal contacts already indicated should take care of both dangers, and where the independent foundations or industry do not also intervene to cover gaps, they are unlikely to escape the scrutiny of university departments ; though it is admitted that the question of borderline fields and interlocking disciplines may require special attention. It may be recalled that Dr. L. V. Berkner, in the United States, has likewise stressed the importance of a diversity of sources of support for academic research, and the same point was made in the National Science Foundation's report on government–university relations, which outlined some principles recommended for the conduct of scientific research and development sponsored by the Federal Government in the United States.

The University Grants Committee suggests that the very success of a branch of research supported by a research council may create a problem of much greater practical importance when a topic previously receiving little recognition develops into a branch of learning of such importance as to require representation within the established departments of a university. Virology, chemical microbiology and biophysics started in this way ; and it is clearly desirable that a line of original scientific work which has proved itself should be financed in the ordinary way from the general university income, and that the university should accept full responsibility for it instead of regarding it as an extraneous activity. The Committee is therefore making arrangements with the research councils to enable universities to assume financial responsibility for work that has hitherto been financed by a research council, when it can be regarded as established and ripe for transfer.

Thus flexibility, even a dynamic approach, are no less important than informality in whatever admin istrative arrangements are concerted for the support and co-ordination of research ; and the recent annual report for 1957–58 of the Advisory Council for Scientific Policy*, which has followed the report on university development, indicates that the Advisory Council is as aware of this as is the University Grants Committee, and that within its own framework it is seeking to foster the conditions in which science and learning best flourish. Indeed, whatever the level of State support for scientific and technological research, whether or not the nation derives the maximum return from that investment depends primarily on whether the right conditions are provided, including not merely equipment but also the supporting technicians and facilities such as libraries and information services in the broadest sense. With Britain's comparatively limited resources, it is the more important that the fullest possible use should be made of the scientific man-power and equipment available ; and it might well be prudent to give greater attention to this point at the moment rather than to open up new fields prematurely.

In its report for 1956–57, the Advisory Council on Scientific Policy indicated that it proposed to consider further whether the existing arrangements for financing pure research in the universities were as satisfactory as they should be ; and it was at the request of the Advisory Council that the University Grants Committee reviewed the nature and extent of its responsibility for financing university research and the part which the research councils and the Royal Society should also play. The reasons which led the University Grants Committee to conclude that the research councils and the Royal Society have an essential part to play, and that its own responsibilities should not be extended to cover it, are those on which its objections to being the source of earmarked funds for new lines of research are based. The Advisory Council on Scientific Policy sets forth the argument at length in its current report, and records that these considerations convinced the Council that the advantages of alternative sources of support for research outweigh any administrative disadvantages they entail. In this connexion it again stresses the value of the financial support given to pure research by the charitable foundations and by industry.

Quite apart from the addition thus made to the total expenditure on university resources, the existence of these alternative sources of support minimizes the danger that entirely novel ventures may go unsupported because of their very unorthodoxy. While the Advisory Council is primarily concerned to see that research workers with promising ideas are able to develop their researches, and that the best use is made of university staff and facilities, it discusses further the detection and filling of gaps in the research effort. This is one of two problems in the existing system that requires special attention : to the other—that of the transfer of responsibility for a line of research once well established—the University Grants Committee, the research councils and the Royal Society, as has been seen, are already giving continuing attention.

The Advisory Council points out that it is the established practice of the research councils to review both the work they themselves support and that being carried on by the universities and other bodies, with the view of identifying gaps in the field and concerting measures to anticipate future trends. From time to time committees of the Royal Society also review the whole range of research activities in science, with the view of detecting and directing attention to lines of research which do not appear to be receiving adequate support or are otherwise neglected. Nevertheless, there are fields of research which do not fall clearly or wholly within the sphere of interest of any one of the research councils, and in considering these the Advisory Council concludes that there is a danger that borderline subjects, and especially those calling for a team of experts from different disciplines, might fail to get the attention which, in the national interest, should be devoted to them. The Advisory Council mentions research into irrigation problems, ecological and physiographical studies and certain aspects of invertebrate physiology ; and there appears to be particular danger that this may arise with some of the work for which the Department of Scientific and Industrial Research has been responsible, if only as a result of the criticism to which the Department has recently been subjected.

The Advisory Council considers it important that a research council should not be restricted by too rigid a definition of its particular field, but should be allowed to expand its ambit to take account of widening interests as these arise. Clearly the research councils and the Royal Society have already the arrangements for informal consultation which, moreover, broadly meet the fundamental criterion that the identification and selection of programmes or projects for research should be in the hands of the scientists themselves. This should facilitate the identification of gaps ; but the Advisory Council does well to point out that it is vital that these arrangements should be kept under constant review and, if necessary, improved to guard against the danger of borderline subjects not receiving support.

While, therefore, such a system of multiple sources for financing research as exists in Britain provides reasonable safeguards both for academic autonomy and the freedom of the scientist and technologist to select and pursue his research objectives, it throws a considerable strain on administrative arrangements. Effective co-operation between the various grant-giving bodies is essential both to secure adequate finance and to prevent serious gaps developing in the research effort. Moreover, it does not appear that by itself it is sufficient to ensure that adequate support is forthcoming from Government sources.

That last is the only broad conclusion that can be drawn from a series of recent reports from, for example, the Committee of Public Accounts and the Select Committee on Estimates, particularly those relating to Treasury control, the Department of

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* Annual Report of the Advisory Council on Scientific Policy, 1957–58. Cmnd. 597. Pp. 22. (London: H.M. Stationery Office, 1958.) 1*s.* 3*d.* net.

Scientific and Industrial Research and the construction of the radio telescope at Jodrell Bank. It is not simply that we have yet to devise an appropriate system of public accounting for the expenditure of public funds on large scientific and technological products. There is also the parallel problem of interpretation and exposition, so that Parliament and public understand clearly what is being done and what is needed, and are prepared to supply the requisite public funds.

In his remark, "The Civil Servant who is at the same time fellow of All Souls is the best guarantee one could have for the autonomy of British universities", Sir Eric Ashby gives a clue as to where the need is most likely to be met ultimately—in an adequate system of public education which will ensure that the ordinary citizen, whatever his or her occupation, has some understanding of what science is about, and that the administrator or Minister or member of Parliament is at least capable of appreciating the scientific issues in questions of public policy which are put to them. This lies, of course, outside the orbit of the Advisory Council, except in so far as its support of technological education and of the teaching of science contribute to that end. Nevertheless, the Advisory Council's eleventh report provides more encouraging evidence than recent reports that it is succeeding in getting greater attention given to varied ancillary factors which, in the aggregate, are of importance in ensuring Britain gets the maximum benefit from whatever resources in man-power and equipment are allocated for scientific and technological research.

CENTENARY OF GRAY'S ANATOMY

Gray's Anatomy : Descriptive and Applied

Edited by Prof. T. B. Johnston, Prof. D. V. Davies and Prof. F. Davies. Thirty-second (centenary) edition. Pp. xxiii + 1604 + 32 plates and 1,277 figures. (London and New York : Longmans, Green and Co., Ltd., 1958.) 126*s*. net.

THE publication of this centenary edition of "Gray's Anatomy" is a unique event, for no other medical text-book has been published under the same title for so long a period. During its life the book has more than doubled in cost but its size has changed from 750 to 1,604 pages, the illustrations from 363 to 1,309 in number; the medical curriculum has broadened, and there is an outcry against many features of pre-clinical teaching and of anatomy in particular. The outcry continues unabated but not unheeded; for twenty years, indeed longer, there has been a steady decline in the amount of detailed knowledge required of pre-clinical students, and increasing emphasis has been laid on principles of functional anatomy. However, structure and function should never be divorced, and generalizations become meaningless if the evidence on which they are based is not available. The incidence of diseases and the appearance of pathological lesions are changing with social conditions and the advent of antibiotics and chemotherapy, but sound diagnosis is still based on accurate observation and evaluation of the normal and of departures from it; and potent drugs can, and alas do, produce permanent disability if injected into main nerve trunks. Certain of the despised minutiæ provide a key to understanding normal and disordered function; the structure of the renal tubules and their blood supply are a case in point. The less information the student is required to remember, the greater is the need for a reliable reference book.

The editors have gone far towards meeting this requirement. The approach to the subject is systematic, but not unfunctional; the salient anatomical features are summarized and their functional significance is stressed in introductory chapters which engender a sense of proportion in the reader's mind. Those preceding the sections of arthrology, myology and neurology are noteworthy, although Fig. 801 in the latter is misleading. The basic features of histology are given with masterly brevity in 54 pages, and the section on embryology relieves the student from the necessity for buying a separate text-book. The minutiæ, as always, are relegated to small print. The few new terms introduced by the Nomina Anatomica, Paris, 1955, are listed and the editorial board "have taken full advantage of their freedom to translate the Latin forma into its English equivalent", and where the Paris term differs from the Birmingham revision the latter has been given in parentheses for the first occasion on which the structure has been mentioned. Loyalty to the decision to adopt this terminology has forced the use of the undesirable and illogical term 'syndesmology' for 'arthrology'. There are numerous references to original papers, many published within the past five years and several as recently as 1956; it was therefore surprising to find no mention of the work of Sholl on the cerebral cortex.

New illustrations include excellent photomicrographs of the cyclical changes in the endometrium and Weigert-Pal preparations of the brain stem, additional X-rays of the wrist and knee joints, and four electron micrographs which remind us of the widening field of cytology. The machine-finished paper, which has been used for the first time, enhances the beautifully clear type and illustrations, a few of which are marred by crudeness of colour and errors of over-printing. The over-stylized drawings of the thoracic skeleton and ligaments of the lumbar spine reappear, and some drawings of cross-sections of limbs suffer on comparison with previous editions by being left uncoloured. Few typographical errors have escaped the proof readers. The editorial board is to be congratulated most warmly on the care and skill expended in the extensive re-editing. This up-to-date book can be recommended unreservedly to medical students, who will find it of value throughout their careers. RUTH E. M. BOWDEN

NOMINA REJICIENDA

International Code of Nomenclature of Bacteria and Viruses

Edited by the Editorial Board of the International Committee on Bacteriological Nomenclature. Pp. xxii + 186. (Ames, Iowa : Iowa State College Press, 1958.) 3.50 dollars.

ARE bacteria a class of plants, Schizomycetes, distinguished by the fact that they reproduce exclusively by simple fission, or are they not ? The name has one virtue, one of the two allowed by

Mortimer Batten to the song of the kingfisher: nobody hears it. Because nobody, including the authors of this book, ever uses it; but the taxonomic system, of which the book is intended to be the instrument, hinges upon its validity.

Apart from the purely biological questions of the mutual and external relationships of bacteria, in which I have myself been interested, it has recently been proved that in the significant characteristic of cell-wall composition bacteria are *sui generis*. They are not plants, and they most decidedly do not confine themselves to simple fission.

There is no question that bacteria require a code of nomenclature, but there is every reason why this should be an effectively separate code, so that we may be spared such exercises as the consignment to limbo of well-known and useful names, *Listerella*, *Pfeifferella* or *Phytomonas*, on the ground that they have prior application to genera of protozoa. *Fritillaria* is both a plant and a pelagic ascidian, but this has not been the cause of any confusion. Greater confusion is likely to be caused by entitling as 'fungus' (*Malleomyces*) an organism that has more in common with the pseudomonads, or by substituting for a name invalidated by prior application to a genus of protozoon, one that has prior application to a green plant (*Listeria*).

The book is mainly concerned with rules for the nomenclature and valid publication of bacterial groupings. There is one rule of primary importance that is not stated, however: that any name, to be valid, must be accompanied by a description which enables the organism in question to be recognized. The firm application of such a rule would obviate the necessity for laboriously working out the priorities of all names published since 1753, since nine-tenths of them would be automatically invalidated.

Not that considerations of priority would appear to have over-riding force in these matters. *Bacterium coli* has many years priority over *Escherichia coli*, nor am I aware of any difficulties arising from its use, but not only does Opinion 15 forbid us to use it, it also informs us: "This Opinion is final unless revoked or modified by action of the International Committee on Bacterial Nomenclature". I wonder how much hope there is of finding that *Escherichia* has prior application in a genus of protozoon.

This part of the Code does not concern itself with the attachment of binomials to viruses, and perhaps that is not wholly a bad thing. K. A. Bisset

MARINE BIOLOGY IN SOUTH-EAST AFRICA

A Natural History of Inhaca Island, Mocambique

Edited by Dr. William Macnae and Dr. Margaret Kalk. Pp. v+163+11 plates. (Johannesburg: Witwatersrand University Press, 1958.) 42*s*.

When the late Prof. C. J. van der Horst went to Johannesburg about twenty-five years ago he looked for a suitable place to conduct classes in marine biology and to undertake research. He found Inhaca Island, and his dream of a marine station there (the only one in the whole of South Africa) was realized in 1951, when the Portuguese Government established the laboratory with the collaboration of the University of the Witwatersrand.

Inhaca Island, which lies on the seaward side of the Bay of Lourenço Marques (Delagoa Bay) in latitude 26° S., is well placed, and is of particular interest from a biologist's point of view, "because it is close to the southernmost limit of the fauna and flora characteristic of tropical east African shores and at the same time it is the northernmost limit of the littoral fauna and flora of Natal and south-eastern Africa. The bulk of the fauna and of the algæ and intertidal marine flowering plants is of tropical origin".

This volume, which has been edited by Dr. W. Macnae and Dr. M. Kalk, is the work of many South African biologists who have visited Inhaca and who have contributed chapters on their special groups. In this way, during the short time the station has been in existence, a formidable list of species has been recorded and included here. The greater part of the book describes the marine life, but there are digressions on the land fauna and on the terrestrial vegetation. For botanists, there are chapters on the ecology of algæ and the sea grasses, with excellent check lists both of these and of the flowering plants.

The general ecology of the shore is well described by Dr. Kalk, and there is a great variety of intertidal habitats from the coral reef (an impoverished one) on the exposed seaward side of the Island, through numerous and often sheltered ecological niches, with substrata ranging from hard rock to sands of different compositions and to thick, water-logged mud in the mangrove swamps. These habitats are rich in species, and have, for example, yielded Prof. J. H. Day no fewer than 160 polychaetes. The major groups, molluscs (Dr. Macnae), crustaceans (Dr. Kalk), echinoderms (Prof. B. I. Balinski) and the fishes (Prof. J. L. B. Smith), are well represented, and the accounts are eminently suitable for the visiting student.

Prof. P. H. Boshoff describes the constitution and the development of the local coral reefs and it seems that species are few and limited to eurythermic ones. *Acropora*, for example, is represented by seventeen species—more than a hundred have been described—so that Inhaca may be a good place to ascertain whether even this reduced number possess distinct biological characteristics, or whether they are merely ecological variants of two or three species. It is perhaps relevant to mention here that the museums of the world contain extensive dry collections of such problem genera bearing a multiplicity of names, the significance of which, if any, remains to be elucidated through study of the living coral.

Keys are provided for the major groups and a habitat list indicates where the intertidal species can be found. Some groups of invertebrates are not included, notably Protozoa, Porifera and Polyzoa. In the brief account of coelenterates, *Muggiaea*, the name of a siphonophore, has been used for a scyphomedusa, and it should be noted that the chondrophores *Velella* and *Porpita* are pelagic hydroid colonies and are no longer considered to be siphonophores. Venomous invertebrates are not adequately noted for the student; there is no mention of the severe sting caused by the hydroid *Lytocarpus*, and the only cone shell specifically noted as causing a severe sting is *Conus ebraeus*, although two other species recorded from Inhaca, *Conus textile* and *C. geographus*, are both well known for their ability to produce fatal stings in human beings.

These minor defects should not be allowed to obscure what has been done; for the student and prospective research worker, this well-illustrated natural history *cum* fauna list is a remarkable achievement and provides a very good introduction to what Inhaca has to offer.

W. J. Rees

HETEROCYCLIC CHEMISTRY

Current Trends in Heterocyclic Chemistry

Proceedings of a Symposium held at The John Curtin School of Medical Research, Australian National University, Canberra, 2nd–4th September, 1957, under the auspices of the Chemical Society. Edited by A. Albert, Dr. G. M. Badger and Dr. C. W. Shoppee. Pp. ix+170. (London: Butterworths Scientific Publications; New York: Academic Press Inc., 1958.) 30*s*.; 5.50 dollars.

Les Heterocycles Oxygenes

Colloques Internationaux du Centre National de la Recherche Scientifique, 64 (Lyon, 5-10 September 1955). Pp. 390. (Paris: Centre National de la Recherche Scientifique, 1957.) 2,500 francs.

The 1,2,3- and 1,2,4-Triazines, Tetrazines and Pentazines

By John G. Erickson, Paul F. Wiley and V. P. Wystrach. (The Chemistry of Heterocyclic Compounds: a Series of Monographs, Vol. 10.). Pp. xii+261. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 9.50 dollars.

"CURRENT Trends in Heterocyclic Chemistry" records the papers which were read during a three-day symposium held in Canberra in 1957, and gives, in addition, a verbatim account of the discussions which followed each paper. The title, however, covers an immense field of current work, which clearly could not be adequately represented in twenty comparatively short papers: moreover, the authors have naturally tended to discuss work in which they were particularly interested. The result is that the volume is almost exclusively devoted to heterocyclic derivatives of nitrogen, with an occasional reference to those of oxygen and of sulphur. A more suitable title would have been "Some Current Trends", or alternatively "Current Australian Trends" (as Prof. A. Albert emphasizes in his introduction).

The papers are of considerable interest, and the fact that each is short and devoted to a strictly limited topic will make them particularly attractive to students. Furthermore, they are not limited to the pure organic chemistry of the heterocyclic systems: the physical side appears in papers such as "Physico-Chemical Studies on Solubilized Porphyrins" by J. N. Phillips, and "Spectrum and Bond-Type in Metalloporphyrins" by J. E. Falk and R. S. Nyholm, and the biochemical side in "Biotransformation Products of ^{14}C-Labelled Codeine and Morphine" by T. K. Adler.

The extent to which these studies of the nitrogen heterocyclic systems have been carried forms a striking testimony to the vigour and enthusiasm of the Australian chemists, more particularly Prof. Albert, the organizer and chairman of the symposium.

One might, however, question the advisability of including in volumes of this type complete reports of the discussions which follow the papers. During an informal discussion many quite minor points can often very usefully be raised, but some participants would hesitate to raise them if they knew that their queries would be recorded in full and published. Reports limited to the major points would avoid this factor.

"Les Heterocycles Oxygenes" contains thirty papers on heterocyclic derivatives of oxygen, and although the majority of the authors are French chemists, the other authors come from many lands and have thus made the colloquium truly international. Many of the papers differ from those usually found in reports of symposia in that they contain a fair amount of new experimental material, with yields, physical data, analyses, etc., of the compounds described: furthermore, each paper is followed by an apparently verbatim account of the discussion it provoked, and the complete collection therefore forms a volume of impressive size.

The papers on purely organic aspects deal mainly with the preparation of derivatives of furan and pyran, and the use of these derivatives in further synthetic work: the derivatives of pyran which receive most attention are naturally those of chroman and of flavone. Several papers deal with the isolation of cyclic oxygen derivatives from plant sources, and with the structure of these derivatives. The last paper discusses the biological action of certain heterocyclic oxygen compounds in the animal body.

An adequate yet brief review of so many topics clearly cannot be achieved, but the volume may be warmly recommended to organic chemists: it is excellently printed and produced apart from two faults, first, the table of contents appears at the end of the volume in place of a real index, and secondly, the fact that publication of the volume lags three years behind the colloquium itself.

The appearance of one more volume in the series on "The Chemistry of Heterocyclic Compounds" is warmly welcome, for the completion of the series will give organic chemists a detailed and authoritative account of almost every aspect of the subject. The six-membered cyclic triazines and tetrazines probably represent to many chemists one of the less-familiar sections of heterocyclic chemistry. Much of our knowledge is at present based on inadequate evidence, and the authors make the reservation that the "structures assigned to many of these compounds rest only upon their modes of formation and upon elemental analyses. We have accepted these structures without comment, except where equally likely or more plausible structures may be written".

Chemists are greatly indebted to the authors for this well-balanced and very thorough account of their subject. The greater part of the volume is naturally devoted to the 1 : 2 : 3-triazines, the 1 : 2 : 4-triazines and the 1 : 2 : 3 : 4-tetrazines, and the classification of the members of each of these groups is particularly clear. It is noteworthy that the final class—that of the pentazines—contains only one member, with considerable evidence that it is actually a tetrazole.

The contents of the volume cover material published up to 1950, with the inclusion of a few later references of particular interest.

The arrangement and the printing of the contents are very attractive, and considerably enhance the ease and pleasure with which the book can be read. It forms a valuable addition to the series.

F. G. Mann

The Story of Evolution

By Sir Julian Huxley. Pp. 72. (London: Rathbone Books, 1958.) 17*s.* 6*d.*

A SURVEY taken by the Audience Research Department of the B.B.C. showed that, despite developments in the teaching of biology in secondary schools, few members of the general public have much accurate knowledge of the theories of evolution and the facts upon which they are based. What better choice, therefore, than Sir Julian Huxley to tell how living things have evolved in a book meant for the layman and designed to combine education with entertainment. Evidence to support the theories of evolution is succeeded by an account of the mechanics of the process, the contemporary attitude to evolution and how it is likely to proceed. All this is explained in language which, though not difficult for the non-specialist to follow, lacks nothing of the precision contained in the author's standard and well-known work, "Evolution: The Modern Synthesis". The text forms a small part of the whole, however, and mainly serves to link the rich collection of attractively coloured diagrams, paintings and photographs; all the diagrams have been prepared by the Isotype Institute.

The photograph of T. H. Huxley on the cover-plate may serve to remind readers of the part played by Sir Julian's grandfather as Darwin's bull-dog three generations ago; this attractive volume will support the grandson's claim in the present generation.

T. H. HAWKINS

Lubrication Science and Technology

Vol. 1, No. 1. Edited by John Boyd. (Publication of the American Society of Lubrication Engineers. ASLE Transactions, Vol. 1, No. 1.) Pp. vii+231. (London and New York: Pergamon Press, 1958.) 105*s.* net.

DURING the past dozen years or more the American Society of Lubrication Engineers has been publishing in its monthly journal, *Lubrication Engineering*, a wide range of articles on lubrication problems. In addition, the Society has held annual conferences at which many papers have been presented, and has participated in conventions on lubrication organized by other scientific and technical bodies. Because of these activities and the increasing interest being shown in the field of lubrication, the Society has decided to publish on a semi-annual basis a volume of transactions to be known as "Lubrication Science and Technology". The first volume, under the editorship of John Boyd, has now appeared and contains nearly thirty articles.

The contents cover an extensive range of interests and appear to fall into three main groups. In the first group are articles dealing with the practical choice of metals and lubricants for specific applications, factors governing fatigue in bearings and gears, the phenomenological wear-behaviour of piston rings and the practical behaviour of solid lubricants. In the second group are papers on the more fundamental level dealing with the mechanism of boundary lubrication and the dependence of wear on specific interfacial interactions: in this group are two papers which attempt to approach metal-machining operations in terms of a rate-process mechanism. The third group deals with design problems and includes papers on finite journal bearings, hydrostatic bearings and the elasto-hydrodynamic behaviour of slider-bearings. There is also a short impressive paper on the design of thrust bearings which can operate up to loads of 2,000 tons or more. Two papers which reflect the atomic age deal with radiation damage in lubricants and lubrication by liquid metals.

It is clear from the selection of the papers included that a serious attempt has been made to balance technological and fundamental work. Nevertheless, the overall impression is that this volume reflects the Society's intention, clearly enunciated in the preface, namely, "to encourage the pursuit and dissemination of the basic technical information necessary for solving industry's problems" in the field of lubrication.

D. TABOR

Planetary Co-ordinates for the Years 1960–1980

Referred to the Equinox of 1950·0. Prepared by H.M. Nautical Almanac Office. Pp. xix+160. (London: H.M. Stationery Office, 1958.) 30*s.* net.

THIS volume is very much more than the ephemeral publication which its title might suggest. It is a continuation of two earlier publications which cover the years 1800–1940 and 1940–60 and extends in convenient form for a further twenty years the data which are needed in the computation of the positions of the smaller bodies in the solar system. The tabular matter is preceded by an introduction in which is given a detailed comparison of the methods for computing the perturbations of comets and minor planets, and at the end of the volume there is a collection of all the formulæ which are needed in eight different methods. These methods are scattered widely in the literature, and most of the text-books which discuss any of the methods do so from an academic point of view. Astronomers and students beginning the study of orbit computation have often felt the need for a more practical approach to the subject as a supplement to theoretical studies, and they cannot do better than master the contents of the descriptive pages of this volume. As a Government publication no names appear on the title page, but from the preface we learn that the authors were Dr. J. G. Porter, Dr. G. A. Wilkins and Mr. M. P. Candy, and we express to them our compliments on their excellent work.

R. H. GARSTANG

Aggression

By Dr. John Paul Scott. (The Scientist's Library—Biology and Medicine.) Pp. xi+149. (Chicago: University of Chicago Press; London: Cambridge University Press, 1958.) 28*s.* net.

THIS book claims to give "a concise account of scientific knowledge about aggressive behaviour in modern society—its causes, control and consequences". If this is what the reader expects, he will be rather disappointed. He will find two chapters which are reasonably documented. One discusses the physiology of aggression and surveys briefly some of the relevant work of Cannon, Bard, Ranson, Hess, Masserman, and Gellhorn. The other deals with hereditary influences, chiefly sex, size and breed differences in a number of species. The chapters concerned with psychological and social factors fall short of what might have been achieved on the basis of existing literature. In particular, the treatment of developmental, psychiatric, and anthropological aspects of aggression is far from adequate.

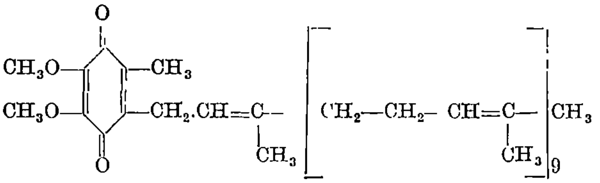
The author states that his primary aim is "to take the important results from current animal research and relate or contrast them with the facts of human behaviour". He has been more successful, however, in reporting the results of animal studies than in giving a convincing account of their bearing on the "facts of human behaviour".

J. COHEN

UBIQUINONE

By Prof. R. A. MORTON, F.R.S.
Department of Biochemistry, University of Liverpool

UBIQUINONE is a new substance of considerable biological interest which possesses the structure:



(I)

It would perhaps be more correct to say that this is the formula for the first of the ubiquinones, as there is already evidence of a plurality of compounds differing only in respect of the long side-chain.

Research on this compound has an interesting and perhaps instructive history. In 1950 G. N. Festenstein[1] obtained from the material lining the horse's gut a substance with an absorption peak at 272 mμ, *E*(1 per cent, 1 cm.) 195, an inflexion at 330 mμ, *E*(1 per cent, 1 cm.) 14 and a weak band at 400 mμ, *E*(1 per cent, 1 cm.) 8. This substance was labile to alkali but could be isolated either from tissue or from its unsaponifiable fraction. The work arose out of earlier investigations at Liverpool on intestinal tissue. It had been found: (*a*) that many species of fish contained large amounts of vitamin A in the intestinal epithelia and in the pyloric cæca; (*b*) that carotene could be converted to vitamin A in the absorptive part of the animal gut; and (*c*) that cholesterol could be dehydrogenated in the gut wall to form provitamin D. Festenstein's study revealed the presence of small amounts of intermediates between carotene and vitamin A as well as the existence of the new 272-mμ substance.

The yield from horse intestine was small, and J. C. Cain[2] began a systematic study of the minor constituents of unsaponifiable matter in liver in the hope of isolating enough of the 272 mμ substance to identify it. Large amounts of liver tissue (horse, ox, sheep) were worked up and the presence of the new substance in liver was established. Liver was not, however, the best raw material to have chosen, although it was natural for this mistake to be made in a laboratory much concerned with vitamin A. Horse liver and ox liver contain substantial amounts of carotenoids as well as of vitamin A, and these substances give rise to artefacts on prolonged processing. In the course of the chromatographic separations, cholest-3 : 5-dien-7-one accumulated in some fractions, and as the ultra-violet absorption spectra of this compound and the new substance are very similar near 270 mμ, it was not always possible to distinguish the two compounds.

Meanwhile, J. S. Lowe[3] and F. W. Heaton[4-6], in an attempt to throw light on the systemic mode of action of vitamin A, had been comparing the unsaponifiable matter, obtained from the livers of rats deficient in vitamin A, with corresponding fractions from the livers of control rats receiving small doses of vitamin A. Similar studies were made on other organs and tissues[7], and a standardized chromatographic procedure facilitated separations. The most interesting fractions were designated SA and SC, the former being the 272 mμ substance. The amounts of both substances SA and SC were greater in the livers of rats deficient in vitamin A than in those of the control animals, but there was little difference in the other organs. The changes in SA- and SC-content of rat liver did not appear in the livers of fowls or guinea pigs deficient in vitamin A. This finding reduced the likelihood that changes in substances SA and SC were direct consequences of the deficiency state. The absence of vitamin A, however, made it technically easier to isolate rich concentrates of substance SA.

Heaton and Lowe[4] obtained enough of substance SA from rat liver for preliminary characterization. A preparation showing *E*(1 per cent, 1 cm.) 272 mμ, 174 and $\lambda_{\text{min.}}$ 234 mμ (*E*(1 per cent, 1 cm.) 36·7) was examined in an infra-red spectrometer and was analysed for carbon and hydrogen. The molecular weight was determined by the Rast method, using both camphor and exaltone as solvents. The results agreed (430 and 433) and seemed trustworthy. It is now known that this was a good preparation and that the analyses were satisfactory, but the molecular weights were almost exactly half the true value. This failure of the Rast method led the whole investigation astray for a time.

The chromophoric properties of substance SA were matched very closely indeed by those of a type of ene-dione steroid structure occurring in cholest-8 : 9-en-7 : 11-dione[4,8]. The analyses and molecular weight made it necessary to explore the possibility that SA was a polycyclic substance of steroid nature. Attempted dehydrogenation (Wohl–Ziegler method and also palladized charcoal) gave no evidence of a polycyclic ring system. G. M. Wilson[9] prepared and examined a number of steroids and related substances containing the 8 : 9-en-7 : 11-dione grouping and showed that they were quite distinct from SA.

It now became clear that substance SA was a normal constituent of many animal tissues. N. F. Cunningham[10] had determined the SA-content of liver, and J. Vernon[10,11] the SA-content of kidney in many species. L. Mervyn[12,13] had found substance SA in human blood, heart and kidney, and also in a fœtus. Miss N. Fahmy[14] had found substance SA in the spleen and pancreas of various species, including man. In the course of a study of yeast unsaponifiable matter a substance, showing the SA spectrum ($\lambda_{\text{max.}}$ 272 mμ, *E*(1 per cent, 1 cm.) 167 in cyclohexane) and other properties, had been isolated (but not crystallized) by Heaton, Lowe and Morton[15]. F. W. Hemming and J. F. Pennock[16] had meanwhile observed that SA was mainly to be found in the mitochondrial fractions of liver and kidney tissue.

Wilson[9] prepared several batches of SA fractions from pig liver, and after rechromatography he was able for the first time to crystallize the compound. Pig liver was chosen because it is normally almost free from carotenoids and is not rich in vitamin A. When the crystalline material was analysed the results agreed well with the earlier figures, but the Rast molecular weights were disconcertingly variable and higher. These values might have been due to partial dimerization, but the crucial importance of the molecular weight made it necessary to use other methods. The Barger method of isothermal distillation led to a molecular weight of 869 (chloroform as solvent) or 995 (acetone as solvent). Cryoscopic determinations using cyclohexane as solvent led to values from 890 to 1,000 (Hemming and Pennock).

SA was readily reduced by zinc and acetic acid to give a compound showing $\lambda_{max.}$ 291 mμ and E(1 per cent, 1 cm.) 52 (in cyclohexane). The infra-red absorption spectrum showed that the carbonyl bands of substance SA had been replaced by hydroxyl bands. The reduced form was readily re-oxidized to SA by shaking with alcoholic ferric chloride, but it formed a stable acetate. The oxidation-reduction potential of the system SA – reduced SA was found to be $E_0 = 0{\cdot}542$ volt (Wilson). Perbenzoic acid titration indicated 7·5 double bonds on a basis of a molecular weight of 642, or 10 double bonds on the basis of a molecular weight of 860. The low value of E(1 per cent, 1 cm.) for the absorption of reduced SA favoured a high molecular weight. W. M. F. Leat and J. F. Pennock studied the catalytic hydrogenation of SA and recorded an uptake of hydrogen consistent with 8 or 11 double bonds, depending on whether the molecular weight was taken to be 642 or 856. The fully hydrogenated compound was readily oxidized by ferric chloride and the absorption spectrum of SA reappeared almost quantitatively. The new product, however, took up only a small proportion of hydrogen. The whole operation was repeated on a larger scale, and it was found that this proportion was 1/11 that shown by substance SA itself. The molecular weight was thereby finally fixed at about 860 by an indirect method[17].

The behaviour of substance SA was thus consistent with a quinone–hydroquinone system as the chromophoric grouping, with a side-chain transparent to ultra-violet rays and containing 10 unconjugated double bonds. The largest fully characterized molecule of this type was until recently squalene, $C_{30}H_{50}$, with 6 unconjugated double bonds, although many years ago Channon[18] isolated a compound $C_{45}H_{76}$ from liver. Dimter[18] found this hydrocarbon, which he called hepene, in adult mammalian liver but not in fœtal liver, and confirmed the formula $C_{45}H_{76}$. Vitamin K_2 has been hitherto accepted as 2-methyl-3-farneso-farnesyl-1 : 4-naphthoquinone, but it has recently been found (Isler *et al.*[19]) that the main vitamin K-active substance of bacteria has a C_{35} side-chain instead of a C_{30} side-chain.

The possibility that substance SA was related to vitamin K was rejected: (*a*) because of the absence of the four narrow absorption bands in the region 240–280 mμ; (*b*) because the value of 0·542 volt for E_0 was too high; and (*c*) because dehydrogenation did not give a naphthalene spectrum. This meant that substance SA was probably a benzoquinone derivative, but only half the oxygen content could be accounted for in this way. Alkoxy determinations were made (7·07 per cent), and on the basis of a molecular weight of 860 two methoxyl groups became probable. Their presence would also contribute to the lowering of the oxidation-reduction potential of *p*-benzoquinone from 0·715 to 0·542 volt.

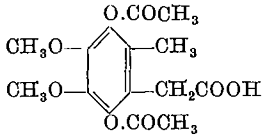
Towards the end of 1956, when the perbenzoic acid titration had indicated that substance SA contained a 'polyisoprenoid' system, the help of Dr. O. Isler, of Hoffmann–La Roche at Basle, was sought because of his great experience in the synthesis of such groupings. It was also felt that the scale of preparation of substance SA would have to be increased beyond the capacity of a university laboratory. Actually, J. Y. F. Paterson, Hemming and Pennock succeeded in obtaining 3 gm. of crystalline SA after considerable effort and expenditure on solvent, and Dr. U. Gloor, of Hoffmann–La Roche at Basle, obtained some 37 gm. by following on a fairly large-scale plant the procedures worked out at Liverpool. Dr. O. Schindler, of the University of Basle, undertook further structural investigations preparatory to projected synthetic work.

In 1957 (July 9) Dr. R. L. Lester, of the Institute of Enzyme Research at the University of Wisconsin, sent to Liverpool a copy of a note[20] on the isolation of a suspected quinone (*Q*275) from beef heart mitochondria. The covering letter stated "after this note was submitted we became aware of the interesting work of your group concerning the characterization of an unsaponifiable lipid material with $\lambda_{max.}$ 272 mμ (*Biochem. J.*, 59, 558; 1955). The ultra-violet and visible absorption of the material we have isolated corresponds very closely to your material. Since on reduction with potassium borohydride we find considerable absorption remaining in the 290 mμ region we thought that this might indicate a quinone–hydroquinone reaction. We would be happy to have your comments in this regard". In reply (July 12) a very full account of the results obtained at Liverpool was sent, including carbon and hydrogen analyses, determinations of molecular weight, infra-red and ultra-violet spectra, oxidation-reduction potential, perbenzoic acid titrations, etc. Mention was made that a steroid structure and many postulated naphthoquinone structures had been ruled out. Dr. Lester's reply (August 29) was most interesting. In acknowledging the letter of July 12 on behalf of Drs. Crane and Hatefi he wrote: "The generous information which was supplied leaves us in no doubt that SA, if not identical with Q275, is indeed a very close brother. The properties and analyses are quite close—even concerning the difficulty in obtaining a reliable molecular weight determination. I notice that several of the formulæ described in the letter contain an alkoxyl group—are your alkoxyl values similar to ours? Is there a possibility that an alkoxyl group is due to the presence of alcohol in the isolation? We plan an ozonolysis of the acetate derivative as a means of getting at the nucleus of the compound. Incidentally, Q275 shows no vitamin K activity in the animal assay". A summary of results was given showing very good agreement with those from Liverpool.

By this time it had clearly become necessary to summarize the Liverpool experience and to find a name for SA or Q275. Accordingly, Morton, Wilson, Lowe and Leat[17] suggested 'ubiquinone', and in their publication made reference to the work of Crane *et al.*[20].

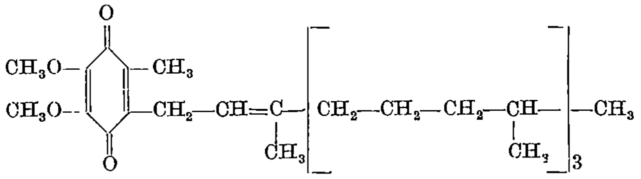
The number of possible structures having been narrowed down, it was decided to search for model substances. The desiderata were a fully substituted quinone (since ubiquinone does not give the Craven test) containing two methoxyl groups. Aurantiogliocladin, 2 : 3-dimethoxy-5 : 6-dimethyl-*p*-benzoquinone had been isolated from a species of *Gliocladium* by Vischer[21] and synthesized unambiguously from *o*-4-xylenol by Baker, McOmie and Miles[22]. A sample of aurantiogliocladin was kindly provided by Prof. W. Baker. This substance was found to show almost exactly the same ultra-violet absorption spectrum as perhydro-ubiquinone. The intensity of absorption E(1 per cent, 1 cm.) 272 mμ = 775 corresponds with a molecular extinction coefficient of 15,190. On the assumption of a molecular weight of 860 for ubiquinone, the E(1 per cent, 1 cm.) value would be 176, which is correct within the uncertainties of the experiment. The behaviour of aurantiogliocladin in ethanolic alkali was exactly similar to that of ubiquinone, although the sequence of chemical changes is not yet clear. Prof. Baker also provided a sample of 3-methoxy-2 : 5-toluquinone, and Dr. Isler and Prof. J. H. Birkinshaw provided samples of toluquinones with two methoxyl groups in the 3 : 4-, 4 : 6- and 3 : 6-positions. The spectra made it extremely probable that ubiquinone was an *o*-dimethoxy compound.

Dr. Gloor had also obtained methoxyl determinations (7·2 and 7·32 per cent), and Dr. Schindler had been able to convert the alkyl iodide obtained into the 3 : 5-dinitrobenzoate ester and had proved by melting point, mixed melting point and paper chromatography that the ester was indeed a methyl ester. This removed any doubt that the alkoxy determinations referred to methoxyl groups. Ubiquinol was obtained ($\lambda_{max.}$ 291 mμ, E(1 per cent, 1 cm.) 50) by reducing ubiquinone by means of hydrogen, using a partially poisoned palladium catalyst, and ubiquinol diacetate was crystallized; melting point, 37° C.; C, 79·5, 79·85 per cent; H, 9·93, 9·96 per cent; $C.CH_3$, 6·54 per cent. (Kuhn–Roth determinations at Liverpool gave similar low results, but this is not unusual for the method.) By ozonolysis of ubiquinone Dr. Schindler obtained acetone, lævulinic acid and a ring compound (II):



(II)

Dr. R. Rüegg had synthesized a compound, (III), which gave the same ring compound:



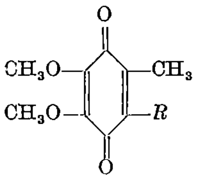
(III)

The dihydroderivative of (III) showed the same infrared absorption peaks as perhydroubiquinone, but the relative intensities were different.

Ubiquinone is in some sense a vitamin for the animal (inasmuch as the synthesis of the benzene ring cannot be effected), but until its biogenesis has been established its status in this respect remains uncertain. N. F. Cunningham[23] showed that guinea pigs deficient in vitamin C were normal in respect of substance SA, as were rats deficient in vitamin D. W. E. J. Phillips (unpublished work) has shown that animals deficient in vitamin K (made so by incorporating sulphadiazine into a diet lacking vitamin K) showed normal ubiquinone content. Mervyn's finding of ubiquinone in a fœtus probably rules out dependence on intestinal micro-organisms. Deprivation of vitamin E did not influence the level of ubiquinone. No diet at present in use for inducing deficiency of known fat-soluble vitamins has so far interfered with ubiquinone contents.

At the Fourth International Congress of Biochemistry held in Vienna in September 1958, Y. Hatefi read, on behalf of the Wisconsin group, a paper dealing with the coenzymic role of Q275 (ubiquinone), and Prof. E. C. Slater[24], of Amsterdam, discussed the biological role of ubiquinone in a survey of the role of tocopherol. In the discussion, M. Tishler, of the organic research group of Messrs. Merck, Sharp and Dohme, gave good evidence[30] for formula (II) for Q275.

The structure of ubiquinone was disclosed at the Sheffield meeting of the Biochemical Society (July 18) by Fahmy *et al.*[25] and quoted by Slater on the basis of the precirculated abstract. With a long chain of unconjugated double bonds it is obvious that neither *cis-trans* isomerism nor partial hydrogenation can be ruled out, any more than side-chains with less than fifty carbon atoms. There may, indeed, be many ubiquinones. Already much interest is being shown in the biochemistry of ubiquinone[26]. The Wisconsin group led by D. E. Green[27] indeed approached the subject through the study of mitochondrial enzyme systems, and because of this they have suggested[28] the designations mitoquinone and co-enzyme Q. In view of the use of Q to designate an enzyme of great importance in carbohydrate biochemistry, the latter suggestion has obvious disadvantages. Moreover, much remains to be discovered concerning the biochemical function of ubiquinone. Although the substance is found in mitochondria, the name 'mitoquinone' is perhaps less happy than ubiquinone with its reminder of widespread occurrence. The term ubiquinone may be used for all substances having the structure:



where R is an unsaturated side-chain. This can be described separately.

The ubiquinone of yeast has been proved by Gloor *et al.*[29] to differ from that of heart tissue, and at Vienna, Tishler also referred to a multiplicity of related compounds. The degree of purity needed for characterizing such compounds is not easily obtained on a small scale.

Detailed proof of the structure of ubiquinone will be given in a forthcoming joint publication by the Liverpool and Basle groups in *Helv. Chim. Acta.*

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INCH-METRIC CONVERSIONS IN BRITISH STANDARDS

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WHEN legislation was first introduced in the United Kingdom to permit the use of the metric system of units where desired, provision was made to enable those who had to deal with metric measures to convert them into their equivalent values in the British system. A table of equivalent values was included in the Weights and Measures Act, 1878, but it was not until 1898 that a table of equivalents for weights and measures used in trade was prescribed in law (Statutory Rules and Orders No. 411). These equivalents include conversions from metric to British units and vice versa, but their primary purpose was to enable such metric measurements as were encountered in trade to be expressed in the usual, that is to say, the British, system of units. The use of these conversion factors has since extended, partly as the result of increased trade with countries using the metric system and partly as the result of certain industries in Britain using the metric system. To-day many conversions enter into the specifications found in British Standards. "Conversion Factors and Tables" (B.S. 350), which is now undergoing revision, gives a wide range of information regarding conversion factors in general. The concurrent use of both systems of units is recognized by the International Organization for Standardization (ISO), which makes due provision for conversions between British and metric units. The change to the metric system in India has also contributed to the need for publication of authentic conversion factors.

Of the conversion factors in use, those for the conversion of inch and metric sizes are of great importance in trade in countries using the metric system. Such conversions are needed, not only for describing equivalent nominal designations in the two systems but also for the purposes of functional interchangeability between articles made to specifications in either system of measurement. In many cases precise dimensional interchangeability is required. Such precise conversion of inch and metric sizes sometimes necessitates a close examination of the basis of the accuracy of the conversion factor used.

Basis of Conversion

Since the British yard and the metre are defined by reference to the material prototypes called respectively the imperial standard yard and the international prototype metre, the relation between these is a matter for experimental determination. One such determination had been made a few years before the issue of the Order in Council of 1898, and the result was included with the basic equivalents given in the Order. For the purposes of trade, rounded conversion factors were legalized, and the factor 1 inch equals 25·400 mm came into use. This round value was estimated to be correct to within one part in a million. It was afterwards applied to other conversions than those for measures of length occurring in trade, and was used, for example, in the determination of conversions for pressure and stress and other quantities, as required in science and industry.

In the first edition of "Conversion Factors and Tables" (B.S. 350), issued in 1930, the use of the round factor 1 inch equals 25·4 mm was recommended. So far as accuracy was concerned, this simple factor was amply sufficient for most purposes, and only in exceptional cases where fine measurements were involved was there any need to use a more precise conversion.

In two respects, however, it became necessary later to reconsider the appropriateness of using the factor. A further determination of the relationship between the yard and the metre (made in 1922 by the National Physical Laboratory on behalf of the Board of Trade, which has the custody of the imperial standard yard) showed that the round factor 1 inch equals 25·4 mm was then true to within two parts in a million. While confirmatory measurements made in 1932 indicated that any change in the relationship was very small, a further determination in 1947 revealed a progressive shortening of the imperial standard yard.

In the meantime, metric measures were of sufficient importance in American industry to lead to the adoption of a simple factor for converting inch to metric sizes. In 1933, the American Standards Association approved the adoption of the round factor 1 inch equals 25·4 mm for industrial use in its standards. The adoption of the same conversion factor for industrial purposes by Britain and by the United States was of evident advantage to both countries. The factor was sufficiently simple to enable, for example, gear wheels having 127 teeth to be used in machine tools and measuring machines for the direct conversion of inch to metric measures.

Status of Round Factor

The factor 1 inch equals 25·4 mm does not purport to define the inch in either country. In Britain the inch is defined by reference to the imperial standard yard, as prescribed in the Weights and Measures Act, 1878. In the United States the inch is derived from the metre by means of the definitive relationship, 1 yard (US) equals (3600/3937) metre. The difference between the British and the United States inches amounts to four or five parts in a million, the former being the smaller. The round factor 1 inch equals 25·4 mm corresponds to an inch which lies approximately midway between these two inches and can, therefore, be regarded as representing either of them with an accuracy of two (or three parts at most) in a million.

While for most purposes this difference is not of serious consequence, difficulties have arisen in regard to some types of precision engineering products which are made to very fine tolerances. In such cases products found acceptable in the United States might be rejected in Britain, and vice versa. It is significant that greater interchangeability of precision products among the different countries using either system of units is called for by modern conditions of life, apart from the experiences of the Second World War. Moreover, an urge in this direction comes also from International Standards conferences and from the defence requirements of several countries.

Proposals to Re-define the Inch

The fact that the inch is not uniquely defined throughout the world presents an embarrassing problem from national and industrial points of view. The continued use of the imperial standard yard (the legal standard) as the fundamental standard of length in the British system, in view of the evidence of a progressive decrease in its value in terms of the international metre, accentuates the difficulties encountered in reference to fine measurements of length.

About twenty years ago, a proposal to redefine the inch as exactly equal to 25·4 mm, corresponding to 1 yard equals 0·9144 metre, was made in Commonwealth countries and in the United States. This proposal, with a similar one for the pound, was discussed by British and American metrologists during the Second World War and was put forward by the British Commonwealth Scientific Official Conference in 1946. It was also recommended by the Inter-Departmental Committee on Weights and Measures Legislation in 1951. Legislation to give effect to these proposals in Britain has not so far been enacted. In the United States a similar proposal had been made before the Second World War, but had met with opposition from certain engineers and surveyors, including the Coast and Geodetic Survey. Further efforts were made in the years following the Second World War, but the same opposition again prevented legislative action being taken. It is now proposed by the U.S. National Bureau of Standards that an 'international yard', defined as exactly equal to 0·9144 metre, should be established by negotiation with the major English-speaking nations and should be used generally for scientific and industrial purposes. This approach would not require legislation by Congress, and the Coast and Geodetic Survey could continue the use of its present units so long as it is considered desirable.

In Canada the change was effected in 1951 by legislation defining the yard as equal to 0·9144 metre exactly. In Australia, provision for a National Standards Commission, to establish standards for various units of measurement, was made in the Weights and Measures Act of 1948, but no formal pronouncement for the yard or inch has yet been made.

Effects of Proposals on British Standards

It is too early to foresee the outcome of these proposals in Britain and the United States. A general adoption of the proposals for unifying the inch would remove all doubt as to the precise meaning of an inch and would translate, from an approximate to a definitive basis, the factor 1 inch equals 25·4 mm which has hitherto been used so extensively in different countries, and in particular in British and American Standards. All inch and metric conversions of length in British Standards would then be on a true and exact basis.

The British Standards most concerned are "Precise Conversion of Inch and Metric Sizes on Engineering Drawings" (B.S. 2856), and "Conversion Factors and Tables" (B.S. 350). In these Standards, and particularly in the former, the use of the round factor 1 inch equals 25·4 mm for all purposes of conversion may not at present meet all the requirements of accuracy in exceptional cases of high precision, and reference may need to be made to the best conversion from the particular inch (British, United States or Canadian) concerned. This difficulty would be overcome if the conversion factor were definitive, instead of being approximate.

In B.S. 350, the status of the factor 1 inch equals 25·4 mm is of great importance because the unit of length enters into the conversion of many compound units, for example, mechanical units and heat units. In the revision of this standard which is now being made, the slight differences between the British and United States inches (and likewise the pounds avoirdupois) have been dealt with by assuming a common basis for the inch, namely, 1 inch equals 25·4 mm (and also for the pound, namely, 1 lb equals 0·453 592 37 kg exactly). This enables most of the conversion factors between British and metric units to be applicable also to the corresponding United States units, with the exception of those units, chiefly units of capacity, which are markedly different in the two countries. This treatment in B.S. 350 provides a very good compromise for industrial purposes, coupled with its additional applicability to most United States units.

BACTERIOPHAGE RESEARCH

SECOND ROYAUMONT COLLOQUIUM

IN the summer of 1952, André Lwoff, of the Institut Pasteur, organized an International Bacteriophage Colloquium at the Abbaye de Royaumont near Paris, the first reunion of European and American phage workers since the renaissance of the early 1940's of interest in bacterial virus. That meeting was held at a crucial time in phage research; for it had only just been discovered then that the tail of the phage is the organ of attachment, that the deoxyribonucleic acid of the phage is the carrier of its hereditary information, that genetic recombination of the phage can be understood in terms of population genetics, that the prophage of lysogenic bacteria is located on the bacterial chromosome, and that genetic recombination in bacteria is a unidirectional process involving donor and receiver cells. It was, therefore, fortunate that an international group happened to meet to appreciate these novel findings, which permitted old questions to be reformulated at a higher level of sophistication.

An unfortunate change has occurred since that Colloquium, when it was still the rule that all first-rate phage workers were always aware of everything important in their entire field. In the past six years, phage research has experienced such a remarkable development that there remain few, if any, persons who still retain complete mastery of every aspect of knowledge of bacterial viruses. Hence, it was appropriate that a Second International Phage Colloquium should be held at Royaumont during July 28–August 2, attended by sixty workers from Australia, Belgium, Denmark, France, Germany, Great Britain, Italy, Japan, Hungary, Switzerland and the United States. No papers were read (nor lantern slides projected) at this meeting, nor will there be any publication. Instead, each session was devoted to the discussion of a given topic under the leadership of a chairman, after an introductory talk on the subject by a *rapporteur*, according to the following programme:

TOPIC	CHAIRMAN	RAPPORTEUR
Anatomy of the Phage Particle	E. Kellenberger (Switzerland)	S. Brenner (Great Britain)
Metabolism of Infected Bacteria	R. M. Herriott (United States)	E. Volkin (United States)
Synthesis of Phage Constituents	O. Maaløe (Denmark)	G. Streisinger (United States)
Kinetics of Recombination	A. H. Doermann (United States)	C. Bresch (Germany)
The Elementary Recombination Act	C. Levinthal (United States)	R. Edgar (United States)
Genetic Fine Structure	G. S. Stent (United States)	S. Benzer (United States)
Replication	F. H. C. Crick (Great Britain)	F. W. Stahl (United States)
Prophage and Chromosome, Transduction	E. S. Anderson (Great Britain)	J. Lederberg (United States)
Phage Conversion	B. A. D. Stocker (Great Britain)	N. Groman (United States)
Bacteriocines	G. Ivanovics (Hungary)	P. Frédéricq (Belgium)

As is evident from this programme, the discussions ranged over a wide field, and to attempt a synthesis of their outcome would be a formidable task indeed. Hence only a rather fragmentary selection of a few of the more important developments to emerge at these proceedings can be mentioned here.

Refined electron, optical and chemical studies reported by S. Brenner have shown that the tail of the bacteriophage consists of three proteinaceous parts: an outermost, cylindrical sheath, enclosing a hollow cylindrical core to which tail-fibres are attached at the distal end. The tail fibres seem to represent the real adsorption organs of the phage, since isolated tail fibres are fixed specifically to bacteria and contain almost all the serum-blocking power of the phage, in contrast to isolated sheaths and cores which possess neither of these properties. The phage, it seems, has a spring; for the sheath is a contractile organ which shortens and thickens when the tail of the phage makes contact with the host cell surface. The sheath, furthermore, is the site of action of adsorption co-factors and inhibitors, which affect the adsorbability of the phage by their influence on a reversible interaction between tail fibres and sheath. The following picture of the infection process may now be inferred from these facts: after phage and bacterium have collided, the phage tail-fibres flail about until they have made a stereospecific fit with the bacterial receptor sites and have anchored the particle firmly to the host surface. The sheath then contracts and pushes the core through cell wall and membrane, so that the viral deoxyribonucleic acid may pass from the head of the phage through the hole in the core into the interior of the bacterium.

Once in the interior of the infected bacterium, the viral deoxyribonucleic acid fulfils two tasks. It replicates itself several hundred-fold to produce the hereditary substance for the progeny particles and it induces the synthesis of viral protein. Parts of both of these processes can be seen directly in some striking electron micrographs of phage-infected bacteria, obtained by E. Kellenberger by means of novel staining and ultra-thin sectioning techniques developed in his laboratory. These pictures show how, in the course of intracellular phage growth, the bacterial 'nucleoids' disintegrate to give way to a pool of viral deoxyribonucleic acid, and how this pool at later stages (but prior to its encapsulation into morphologically intact, infective virus particles) crystallizes into hexagonal, pre-phage structures, which break up into free deoxyribonucleic acid and protein 'doughnuts' if the cell is lysed prematurely. The phage precursor deoxyribonucleic acid thus exists in at least two different states before its maturation, a fact which must be reckoned with if biochemical and genetic 'pool' estimations are to be correlated with one another. A revolutionary advance in the study of the role of viral deoxyribonucleic acid in viral protein synthesis was reported by G. Brown, who appears to have succeeded in inducing *in vitro* the formation of small but significant amounts of phage tail antigens by addition of purified phage deoxyribonucleic acid to preparations of disrupted bacterial cells. Brown has already carried out extensive control experiments to establish the reality of the effects produced in this system, which, if confirmed and developed further, bids fair to become a biochemical philosopher's stone. In the discussion of the replication of deoxyribonucleic acid, F. W. Stahl summarized his and M. Meselson's experiment, in which the density of the deoxyribonucleic acid of bacterial cultures initially labelled with nitrogen-15 was examined after various periods of growth in non-labelled medium (containing only nitrogen-14). Meselson and Stahl have shown by means of this procedure that the replication of bacterial deoxyribonucleic acid follows a semi-conservative course. That is to say, exactly as envisaged by J. D. Watson and F. H. C. Crick, the two complementary polynucleotide strands of the deoxyribonucleic acid macromolecule appear to separate from each other for the replication act and join up with single, *de novo* polynucleotide chains to form two replica molecules, each containing one old and one new strand. The capital importance of this convincing experimental confirmation of the Watson–Crick proposal is obvious. It is hoped that one may know soon whether these results can also be extended to the replication of the phage deoxyribonucleic acid.

The work of many phage geneticists in recent years has indicated that genetic recombination is a process which must be intimately associated with the replication of the hereditary material, namely, deoxyribonucleic acid. It is therefore of great interest that C. Bresch presented a new analysis of the population dynamics of genetic recombination in phage, elaborated independently by himself and by F. W. Stahl and C. Steinberg. This treatment represents a generalization of the Visconti–Delbrück theory, not only in that the nature of the elementary recombination act is not presupposed but also in that the pairwise mating-event of the earlier theory is replaced by a 'co-operation' in which the number of participating particles may be greater than two. A generalization of this sort had become necessary for two reasons: first, studies by Bresch and others have revealed a number of facts which do not agree with the Visconti–Delbrück assumption that genetic exchange in phage occurs by breakage and reunion of homologous parts of mated parental structures. Secondly, Bresch has shown by means of a triparental cross that more than two particles 'co-operate' in genetic exchange, so that mating is *not* pairwise. The implications of the demise of pairwise mating for the understanding of the molecular basis of genetic recombination are not yet clear.

In connexion with this same problem, R. Edgar and A. H. Doermann discussed new experiments pertaining to heterozygotes, those unstable phage genotypes which harbour alleles from parents of a mixed infection and which C. Levinthal first proposed as the transient zygotes formed at every elementary recombination event. Edgar concludes from crosses of several closely linked genetic loci that heterozygotes are indeed formed at the moment of genetic exchange. Furthermore, negative interference (that is to say, multiple exchange between three or more closely linked markers at a frequency greater than that expected from linkage data of two factor crosses) occurs at the time of the segregation of the heterozygote. In order to gain further insight into the genetic structure of the heterozygote, Doermann made crosses involving three closely linked markers and compared the frequency of progeny heterozygotic only for either one of the outside loci with the frequency of progeny heterozygotic only for the inside locus. Contrary to the 'overlap' model of heterozygote structure, now favoured by many phage geneticists, which predicts that phages heterozygotic for only the inside locus should be much less frequent than those heterozygotic for either one of the outside loci, Doermann found that all three types appear in roughly equal yield. Although it is now evident that both negative interference and heterozygosis must hold one of the keys to the understanding of the nature of the elementary recombination act, it is difficult to assess how soon a full comprehension of these phenomena may be at hand.

S. Benzer reported his work on mutation in a single genetic region, or 'cistron', of the bacteriophage. By mapping hundreds of independent mutants produced either spontaneously or under the influence of certain mutagens, he has constructed a mutational spectrum and thus obtained an image of the relative mutability of individual loci within a single gene. The spectrum of spontaneous mutations shows a few 'hot' spots at which mutants recur with high probability and a number of other sites mutating with lower probability. The spectra of mutation induced by 5-bromouracil, 2-amino-purine, or proflavine, all of which raise the overall rate of mutation in the cistron by two orders of magnitude, are very distinctive, in that each of the three mutagens creates its own set of 'hot' spots and mutable sites, totally unlike the set of mutable loci identified either among spontaneous mutants or among mutants induced by the other two mutagens. Bromouracil, amino-purine and proflavine, therefore, are specific mutagens, in the sense that each raises the probability of mutation only at definite genetic loci, rather than causing a generalized mutability of the entire genome. Since concrete notions concerning the mode of action of each of these mutagens can already be formulated in terms of the Watson–Crick structure of deoxyribonucleic acid, mutational spectra promise to bridge the gap between chemistry and genetics.

The past decade saw an ever-growing confluence of phage and bacterial genetics, particularly as non-infective prophage turned out to be an integral part of the bacterial genome in lysogeny, and infective phage a carrier of bacterial heredity in transduction. Recent studies on bacterial recombination, lysogeny and bacteriocines, presented at the Colloquium by J. Lederberg, by R. Frédéricq and by F. Jacob, have revealed, however, that the bacterial fertility factor *F*, the prophage and the colicinogenic factor have certain features in common which set them apart from other, or 'regular' bacterial genes. On the basis of these special properties, F. Jacob and E.-L. Wollman have created a new concept, the 'episome', defined as an exogenous hereditary determinant integrated into the bacterial genome by addition to the chromosome instead of replacement of allelic bacterial loci. Besides its integrated chromosomal state, the episome can also exist in an autonomous state, in which it is replicated independently of the rest of the bacterial genome. The episome promises to bring new order into the dialectics of virus-host genetics.

The second International Phage Colloquium can be considered to have been a great success; not only the participants but also phage workers in general must be grateful to its organizers, A. Lwoff and F. Jacob, and to the Rockefeller Foundation which provided financial support. The week of intimate and informal living within the historic Cistercian monastery founded by St. Louis in the thirteenth century once more promoted understanding, collaboration and personal friendship of a truly international nature. There seems little doubt that this Colloquium, like its predecessor, will have a profound effect on the development of bacteriophage research in coming years.

GUNTHER S. STENT

OBITUARIES

Mr. Cecil Warburton

MR. CECIL WARBURTON died at his home in Grantchester, Cambridge, on October 7 at the age of one hundred and four years and eight months. Although he had lost much of his former physical vigour during the past year or two, he retained to the last his remarkable mental clarity, sense of humour and interest in people and current affairs. Warburton's work as an entomologist and arachnologist was known and respected by several generations of zoologists. His modesty and the charm of his simple and generous personality tended to cloak from those not familiar with his work the solid and enduring value of his scientific achievements.

Cecil Warburton was born on February 6, 1854, at Salford. He was educated at Old Trafford School, Manchester, where he later became second master. He attended classes at Owens College, Manchester, and took a University of London external B.A. degree. He went to Christ's College, Cambridge, in 1886, read for the Natural Sciences Tripos, graduated B.A. in 1889, and took his M.A. degree in 1892.

An early interest in spiders directed his zoological studies towards other Arachnida, and mites and ticks later became his main field of study. His knowledge of general zoology was wide, and he was appointed zoologist to the Royal Agricultural Society in 1893, and from that year until 1940 he wrote an annual report for the Society, dealing largely with economic entomology. At first these reports were addressed from the Department of Zoology, Cambridge, but from 1910 until 1940 they came from the School of Agriculture, where he lectured until his retirement in 1932, thus continuing an association with the teaching of agriculture in the University which had begun as early as 1899–1900 when his name appeared in the list of lecturers for the Board of Agricultural Studies. In 1909 Warburton was the author of Chapters 12–18 of Vol. 4 of the "Cambridge Natural History", which dealt with the Arachnida Embolobranchiata (scorpions, spiders, mites and ticks). This was an important and valuable work, and it provided the background to the fruitful association with G. H. F. Nuttall, then Quick professor at Cambridge, beginning in the Quick Laboratory in 1908, continuing in the Molteno Institute from 1921, and lasting until the death of Nuttall in 1937. It was during this period that his main original contributions were published, dealing with mites and ticks and culminating in the publication, by the Cambridge University Press, of "Ticks; a Monograph of the Ixodoidea", by G. H. F. Nuttall, Cecil Warburton, W. F. Cooper and L. E. Robinson. The first volume was written jointly by G. H. F. Nuttall and Cecil Warburton and comprised: Part 1, "The Argasidae" (1908); Part 2, "Ixodidae" (1911); and Part 3, "The Genus Hæmophysalis" (1915).

These studies were of great value to all workers in the rapidly developing subject of ticks as vectors of diseases of man and domestic animals, and they still remain standard works on ticks. Their preparation and publication resulted in a voluminous correspondence and the submission of collections of ticks for identification from all parts of the world. Replying to innumerable correspondents and identifying and reporting upon specimens occupied much of the time and energy of both Nuttall and Warburton for many years. Warburton continued identifying and reporting upon specimens of ticks until 1936, when he was eighty-two years of age; and there can be few, if any, collections of ticks in any country in the world which are not enriched by numerous specimens bearing on the label the words "identified by C. Warburton".

He had been appointed University demonstrator in medical entomology by the Quick professor in 1911, and he retained this post when the Quick Laboratory moved to the Molteno Institute in 1921. Thereafter, until he retired in 1932, his activities were mainly centred on the Institute, and he lectured on parasitic insects and arachnids, and demonstrated to students taking the courses for the diplomas in public health and tropical medicine and hygiene. He retained a keen interest in the Molteno Institute and those who worked in it to the end, and was an occasional visitor until after his hundredth birthday. Not only did he delight in meeting his old friends there, but also he was always pleased to meet new and younger workers, and all were warmly invited to visit him at his home in Grantchester and play croquet, a game at which he excelled until his sight failed in the last couple of years. He never married. All who knew him will feel they have lost a friend who was warm-hearted, generous and of high integrity both in his private and his scientific life.

P. TATE

Prof. Horace B. Dunnicliff

THE news of the death on October 8 of Prof. H. B. Dunnicliff was received with great regret in India. Dunnicliff had been intimately associated with the growth of chemical education of the country for the past fifty years. He came out in 1908 as professor of chemistry of the M.A.O. College, Aligarh, where he taught chemistry until the First World War. In 1914, his services were placed at the disposal of the Khalsa College, Amritsar. In 1917, he was on deputation to the Munitions Board and was transferred to the Cordite Factory, Aravankadu. There he stayed until 1921 and did some very useful work. He was appointed professor of chemistry, Government College, Lahore, in 1922. On the reorganization of teaching of the Panjab University he was appointed University professor of inorganic chemistry. Here, a good school of chemistry was soon founded with the help of the late Santiswarup Bhatnagar. Bhatnagar was in charge of the teaching of physical chemistry and Dunnicliff looked after inorganic chemistry.

I was in charge of the organic chemistry section when Dunnicliff joined the Panjab University. The success of the Lahore School of Chemistry was largely due to the untiring efforts of Dunnicliff to keep the ship on an even keel in the stormy communal waters of the Panjab. He had a keen sense of justice and fair play, which kept the University teaching departments free from communal politics. He was seconded to the Government of India in 1928 with the view of organizing the Central Customs Analytical Laboratories. On his return to Lahore in 1929, his Laboratory acted as the appellate laboratory for all matters relating to analyses performed by the various customs laboratories of the Indian ports. He was allowed to hold the post of special chemical adviser to the Finance Department of the Government of India in addition to his duties as a professor in the Government College and the University. This was a great strain, but he never grudged the extra burden placed on him. The work in connexion with the Customs Laboratory was not light. I deputized for him for two periods when he was on leave and I can affirm that this work was quite a full-time job. Ultimately his suggestion to have a Central Customs Laboratory at Delhi was adopted, and he finally migrated from Lahore in 1939 as the head of this new Laboratory.

During his tenure as professor in the University of the Panjab, Dunnicliff published a large volume of work in collaboration with his students, which earned for the Panjab University a reputation as an active centre of research work. Many of his pupils now occupy important positions both in India and Pakistan. They are all grateful for the helping hand he lent whenever they met difficulties. His migration to Delhi helped in putting the Central Revenues Chemical Service on a firm footing. During the Second World War I was again associated with him in war work. Owing to the large demand for morphine and codeine, the production at the Ghazipur Opium Factory had to be re-organized. He also designed the present morphine extraction plant at Ghazipur. He had a flair for designing plant and equipment. On his retirement from the Central Board of Revenues Laboratories, he joined the Department of Transport, New Delhi, where he had to design portable producer gas plants for use in lorries and motor-cars in order to minimize the use of petrol.

Dunnicliff presided over the Chemistry Section of the Indian Science Congress in 1934. He was on the Indian Committee of the Royal Institute of Chemistry, and he and the late Prof. Gilbert Fowler did much for the Institute in India.

Dunnicliff was a good singer, and many a pleasant evening was spent by his friends at his home; he was also a proficient amateur actor, and during the summer season he produced many plays at Simla.

Dunnicliff will always be remembered in India as a good Englishman who gave it more than he received from it. Those who knew him recognized him as a giver and not a taker. He lived in India at a critical period of her history. His contribution to the growth of science in India was by no means negligible.

He leaves behind a devoted wife, to whom our sympathy is offered. J. N. RAY

Dr. S. L. Smith, C.B.E.

BY the death of Dr. S. L. Smith on October 27, engineering and in particular shipbuilding research in Britain have lost a prominent figure. Those who had the privilege of working with him will remember him as the most kindly and approachable of colleagues.

Stanley Livingston Smith was born in 1889 and received his technical education at the City and Guilds Engineering College, South Kensington, where he graduated as B.Sc. (London) and Associate of the City and Guilds Institute in 1909. A period of practical training at the Thames Ironworks, Shipbuilding and Engineering Co., Ltd., was followed by an engineering inspectorship with the Crown Agents for the Colonies. After a varied career during the First World War, including secret work for the Royal Society war committee and service as an engineering officer in the marine training section of the R.A.F., he returned to the City and Guilds College under Prof. W. E. Dalby. Awarded the degrees of M.Sc. in 1921 and D.Sc.(Eng.) in 1923 for his work on elastic hysteresis in steels, he was appointed assistant professor in 1926 and reader in mechanical engineering five years later. He represented the Imperial College of Science and Technology on the Surrey County Council and was appointed chief engineering inspector of technical institutions.

Just before the outbreak of war in 1939, he was appointed superintendent of the Engineering Department of the National Physical Laboratory. During the War he was responsible for the very varied war-work of that Department; to mention only three items, he was particularly concerned with the development of apparatus for rendering unexploded bombs harmless, gun design (he was a member of the Gun Design Committee), and (with the late Dr. G. A. Hankins) the building for external ballistic work of an 11-in. square supersonic wind tunnel, which until late in the War was the only supersonic tunnel of reasonable size available to the United Nations.

Despite these preoccupations, Smith found time for probably his most notable personal research, producing with Dr. W. A. Wood four papers on the application of X-ray methods to the study of the deformation and fracture of metals. It is, however, as an administrator of scientific research that he will be best remembered. In 1944, he became the first director of research of the British Shipbuilding Research Association, a post which he still held at his death. Under his leadership the Association has become the central research organization in Britain for the shipbuilding, ship-repairing and marine engineering industry. He organized the work of the Association in an unusual way; no laboratory was set up, but a wide variety of research contracts was placed with universities, other research institutions and industrial firms. Among many papers by Dr. Smith covering this work may be mentioned his Thomas Lowe Gray Lecture to the Institution of Mechanical Engineers in 1952 on ship research, that on the resistance experiments with the old Clyde steamer *Lucy Ashton*, modified for jet propulsion to avoid propeller drag, and recent papers on nuclear propulsion.

Smith was made C.B.E. in 1951. He had been a vice-president of the Institutions of Mechanical Engineers and of Naval Architects, and a member of many technical committees on marine (including nuclear) propulsion, structural steel, corrosion and other subjects, as well as of committees of other research institutions. D. G. SOPWITH

Prof. H. J. Logie

PROF. H. J. LOGIE died on November 8 at the age of thirty-nine. His untimely death came at a period when his research had become very productive, and has been a shock and a great loss to all his colleagues and friends. He received his early education at Benoni High School, went to the University of the Witwatersrand as a student in 1936 and graduated bachelor of science in 1938 with firsts in both mathematics and physics. In 1939 he was awarded first-class honours in physics, and in

1940 he was appointed a junior lecturer in physics. He soon resigned in order to go on active service, and at the age of twenty-four attained the rank of major in the Special Signals Services (Radar) of the Union Defence Force.

Prof. Logie rejoined the University staff in 1946. Despite the very heavy teaching duties which the staff undertook on account of the large number of ex-Servicemen returning to South Africa, he took part in an active research programme in the recording of the Witwatersrand earth tremors. He was awarded the degree of doctor of science in 1949 for a thesis on this work.

In 1950 the staff of the Department of Physics agreed to form a team working together in the field of the physics of the solid state, and Prof. Logie spent a year studying the physics of metals in the University of Birmingham. On his return he started experimental and theoretical research on internal friction in metals and alloys. He was chosen as the first occupant of the newly established chair of experimental physics. On taking up his new appointment, Prof. Logie assumed responsibility for work on the changes of electrical resistivity produced by plastic strain in alloys, and on the electrical properties of counting diamonds.

In addition to teaching and research, Prof. Logie played a large part in other University activities, while outside the University he found time for many scientific and public services.

For the last seven years of his life he suffered from ill-health, but it was characteristic of the man that he spared himself so little as to make this generally forgotten. Friends will remember his lively wit and his warmth as a family man. F. R. N. Nabarro

Prof. F. A. Paneth, F.R.S.

Prof. H. Dingle writes: "The obituary notice of the late Prof. F. A. Paneth in *Nature* of November 8 omits to mention one incident which is at the same time so characteristic of the man and so noteworthy in itself as to justify recalling. On his appointment to the chair of chemistry at the University of Durham, Paneth at once began to interest himself in the local scientific associations, and his attention was captured by the then shadowy figure of Thomas Wright, who first discerned the true character of the Milky Way and whose 'Original Theory of the Universe' (1750) was the source of the idea that inspired Immanuel Kant to write his 'Allgemeine Naturgeschichte und Theorie des Himmels'. With his customary energy and enthusiasm, Paneth brought to light a number of forgotten facts and neglected relics of Wright, discovered that two notices in Allibone's 'Dictionary of English Literature', ostensibly relating to two different persons, in fact referred to the same versatile Thomas Wright, and identified Wright's 'observatory'—a round stone tower which he had caused to be erected at Westerton, near Durham, of which the origin had been completely forgotten; it was known locally as the 'Westerton Folly'. Paneth succeeded in arousing public interest, and in June 1950, the two-hundredth anniversary of the publication of the 'Original Theory of the Universe' was celebrated by public meetings at which, among other events, a collection of Wright memorials was exhibited, a commemorative tablet affixed to the tower was unveiled, and a wreath was laid on Wright's grave. Durham has a special reason to honour Paneth's memory".

NEWS and VIEWS

Physiology at Aberdeen: Prof. E. W. H. Cruickshank

Prof. E. W. H. Cruickshank, who has recently retired from the regius chair of physiology in the University of Aberdeen, from which he graduated, is the living embodiment of the 'wandering Scot'. He graduated in medicine in 1910, and one year later he was in University College, London, with Starling. There he made the significant discovery that, in pancreatectomized dogs, the cardiac muscle, unlike skeletal muscle, stores glycogen. This work, however, was interrupted by the First World War, and it was not until 1919 that, at the invitation of the Rockefeller Foundation, he returned to academic life in the laboratory of Erlanger in St. Louis. He then went to the new Pekin Union Medical College, where he had his first experience of building up a new department from scratch. Yet he found time to continue his study of cardiac metabolism; he also worked on respiration and on general metabolism.

The year 1924 found him back in Britain, in Cambridge. Under the influence of Sir Joseph Barcroft, he showed that the spleen, in the dog at least, acts as a reservoir of blood. In collaboration with Anrep he put on a quantitative basis the coronary blood flow in relation to the activity of the heart. Then Cruickshank went to India as the first professor to build up a Department of Physiology and Biochemistry in the Prince of Wales Medical College at Patna. Two years later an invitation reached him to go to Dalhousie University in Nova Scotia. Here he had seven active and happy years devoted largely to research on metabolism of the heart—an authoritative article from his pen is to be found in Vol. 16 of the *Physiological Reviews*. The final 'call' came in 1935 when Cruickshank succeeded his friend, J. J. R. Macleod, in the chair at Aberdeen. Cardiac metabolism continued to be his main preoccupation, although he was also caught up in the general interest in nutrition and wrote a small book on this subject. In his later years, under the auspices of the World Health Organization, he has had the pleasure of visiting many medical schools in parts of the world where he himself had been a pioneer in establishing physiology as an academic discipline.

Prof. J. Laurence Malcolm

Prof. Malcolm, who has recently succeeded Prof. Cruickshank in the regius chair of physiology in the University of Aberdeen, comes from New Zealand. His first degree was B.Med.Sci. of the University of Otago and he then proceeded to the M.B., Ch.B. in 1938—a proper emphasis on the scientific basis of medicine which unfortunately seems to find less support in Great Britain. While still an undergraduate, Malcolm demonstrated in physiology and studied on rats the goitrogenic action of certain diets. He spent a year as house surgeon in a New Zealand hospital and another year as lecturer in the Department of Bacteriology and Public Health at Otago. In 1941 he became senior lecturer in experimental physiology at Otago, where he remained until 1948. There he came under the stimulating influence of Prof. J. C. Eccles, with the inevitable result that his subsequent work has been in the exacting and modern field of neurophysiology. Neurophysiologists suffer from the same disability as the early microscopists, they must design and build their own equipment.

During 1948–49 Malcolm held an exchange lectureship in St. Thomas's Hospital Medical School, London, and then the readership in physiology with Prof. Huggett at St. Mary's Hospital during 1949–52. The following year he was visiting professor in the New York State University at the invitation of Prof. Chandler Brooks. He then returned to the National Institute for Medical Research in London to the Division of Physiology and Pharmacology. There he used most ingenious and delicate electrophysiological methods to study activities in various parts of the brain: he was even able to study conditioned reflexes in unrestrained animals. The emphasis in the study of the central nervous system is rapidly changing from the anatomical and histological approach to the biochemical and pharmacological. In this new and exciting field Malcolm is using his special techniques to obtain records of the influence of various chemical substances on the brain itself.

Geography in the University of Hull: Prof. H. R. Wilkinson

THE late Prof. Herbert King has been succeeded in the chair of geography in the University of Hull by Mr. H. R. Wilkinson, senior lecturer in geography in the University of Liverpool. Prof. Wilkinson was, like his predecessor, a pupil of Prof. P. M. Roxby in the Liverpool School of Geography, graduating with first-class honours in 1939, and in much of his work reflects that School's traditional interest in human geography. Following six years of war-service, he became senior geography master at Bootle Grammar School. He was appointed by Prof. H. C. Darby to the staff of the Department of Geography at Liverpool in 1947, where, following Prof. Wilfred Smith's sudden death in 1955, he was acting head of the Department for four terms. Prof. Wilkinson's special interests have lain in the fields of human geography and cartography, and he has much first-hand experience of Yugoslavia and adjacent areas of central and south-eastern Europe. His published works include "A Geography of Merseyside" (1948), "Maps and Politics: a Study of the Ethnographic Cartography of Macedonia" (1951), "Maps and Diagrams: their Compilation and Production" (with F. J. Monkhouse, 1952), and numerous papers in geographical and other journals. He was an assistant editor of "A Scientific Survey of Merseyside", the handbook prepared for the Liverpool meeting of the British Association for the Advancement of Science in 1953.

Prof. Wilkinson has served as a member of the Council of the Institute of British Geographers and was a member of the British delegation to the International Geographical Congress held in Washington, D.C., in 1952. He has lectured in Austria and Yugoslavia under the auspices of the British Council. To the growing Department of Geography at Hull he brings a varied experience and a wide range of interests in the subject.

The Inter-University Council for Higher Education Overseas

AT the end of February, Mr. S. J. Worsley will complete his term of office as secretary of the Inter-University Council for Higher Education Overseas. Mr. I. C. M. Maxwell, assistant secretary of the Council since September 23, 1952, will succeed Mr. Worsley. Mr. Maxwell was formerly secretary of the University of London Senate Committee on Higher Education in the Colonies, a body responsible for the development and detailed working of the special relationship of the University of London and certain university colleges overseas. He has, therefore, had considerable experience of higher education in the Colonies and is well-known to members of the staffs of the universities and university colleges with which the Inter-University Council is associated.

Soviet International Press Censorship

STRONG criticism of, and protest against, Soviet censorship of science reporters, especially British and American, have recently been made, according to Mr. Victor Cohn, science editor of the *Minneapolis Tribune*. This was particularly evident in connexion with the International Geophysical Year meeting in Moscow during July–August. Mr. Cohn states that Western correspondents had to file their reports in triplicate at the Central Telegraphic Agency in Moscow; these were censored and then returned to the correspondents "15 minutes or two hours or six hours or 24 hours later, or never". Mr. Cohn has given some examples of undesirable censorship exercised by the Soviet authority.

A group of correspondents wrote letters of protest to Prof. Sydney Chapman, president of the Comité Spécial de l'Année Géophysique Internationale. In one letter it was claimed that "in areas where the public of our nations is concerned, there can be no freedom of enquiry or scientific reporting unless there is also freedom to communicate with the public. It would seem intolerable to hold great scientific meetings in a place where their results cannot be communicated to the people who must support science in our countries". On August 5, Prof. Chapman replied: "It is the view of the C.S.A.G.I. bureau that the press should be able to transmit to the public the views of the participating I.G.Y. committee on purely scientific matters". The newspaper correspondents' protest seems justified, and Prof. Chapman's guarded reply encouraging. It is, to say the least of it, very frustrating when a correspondent cannot be sure that his report of a scientific meeting will be cabled, even after it has been held several hours. This form of press censorship, especially where international conferences and the like are concerned, is much to be deplored.

Science and History

"THERE is within you", said Hobbes, "some special cause of intenebration which you should do well to look to"; and Prof. Douglas McKie in his inaugural lecture delivered at University College, London ("Science and History." Pp. 17. London: H. K. Lewis and Co., Ltd., 1958. 2*s*. 6*d*. net), on May 22 has done us a service. The Department over which he has been called to preside was founded after the First World War as a virtual by-product of discussions centring around an institution for a diploma in journalism. After even further consideration a committee was appointed which recommended that the history of science should be a post-graduate discipline including the study of what was at first method of science but has now become the philosophy of science. Instituted in 1924, it has now some sixty students, and its staff, of which Prof. McKie has been one of the outstanding ornaments, has made a name by careful and scholarly research. In these days as scientific journals increase at the rate of more than a thousand a year, synoptic views need more than ever to be authoritative. Prof. McKie's plea that the history of science should be recognized as a branch of history has already been tried by Dr. J. B. Conant, and University College, London, is trying, too. Looking further, he sees the expansion of this field in the history of technology reaching into the history of medicine. Prof. McKie's modesty makes his inaugural address pleasant reading ; one only regrets that it does not include a little autobiography. He, of all men, should be encouraged to tell us of his own writings and work.

Cotton in the Prehistoric Southwestern United States

THE textiles, old or new, of particular areas have formed the subject of a number of reports published in recent years, which have an interest by no means limited to the areas with which they deal. The late Prof. Lila O'Neale's "Textiles of Highland Guatemala" was a notable example dealing with modern weaving, and a recent report (*Trans. Amer. Phil. Soc.*, N.S., 47, Part 3 : The Cultivation and Weaving of Cotton in the Prehistoric Southwestern United States. By Kate Kent. Pp. ii+457–734. 4 dollars), which is concerned mainly with ancient examples, should command an equally wide interest, not only among textile specialists but also among those who are interested in New World archæology. The work has entailed widespread research among museum collections, as well as painstaking study of individual examples, many of them in poor condition. A great deal of this report naturally consists of descriptions of specimens, but the admirable drawings make it easy to follow the processes and to pick out what is of general interest. The bulk of the material available dates from between A.D. 1000 and 1400, but evidence is given for the use of the loom in the area at least as far back as A.D. 700. It may be remarked that it was far older in some other parts of America, and it will be surprising if it does not eventually prove to have reached the south-west of the United States at an earlier date. The account is not limited to loom-woven fabrics, and it includes such processes as twining, besides netting and other single-element techniques. It was found possible to distinguish the products of several sub-areas in the region.

Of particular interest are suggestions as to how and when various processes were introduced from Mexico from a possible ultimate source in Peru. Brief comparisons are made between looms and processes popular in Peru and the south-west of the United States ; twills, for example, are common in the latter and rare in Peru, where warp floats enjoyed a vogue which was lacking farther north. The wide loom, horizontal or vertical, with fixed beams, was largely used alongside the belt loom in the south-west of the United States, whereas the belt loom predominated farther south, and the evidence for the use of a stationary loom in ancient Peru is still unsatisfactory. The Peruvians always had a taste for finger weaves, whereas there was a greater dependence on loom processes in the south-west of the United States. Observations of this sort direct attention to the desirability of a synthetic study of weaving in different parts of ancient America, a work which would be of great interest and value. This report would form one of its foundations.

Silver Jubilee of *Polarforschung*

THE Archiv für Polarforschung at Kiel has recently published two special issues of its journal, *Polarforschung*: one to celebrate the journal's twenty-fifth anniversary, and the other in memory of Alfred Wegener. Apart from special emphasis in the second on the German Greenland Expedition of 1930–31, these two issues follow the pattern of their predecessors. There are short articles on a wide variety of subjects ; but scientific results of expeditions are not normally to be found here. The jubilee issue, for example, includes a summary of the weather at Vorkuta by an ex-prisoner there, a discussion of dreams during the polar night by a doctor, a survey of volcanic activity in Iceland since 1700, and many more notes further exemplifying this diversity. The somewhat austere layout and type face, together with the absence of diagrams or illustrations, should not deter the careful reader, who will find information of interest and value not available elsewhere. Polar specialists will be sorry to hear that Dr. Max Grotewahl, the founder and organizer of the Archiv für Polarforschung, died on September 6, shortly after the appearance of these two issues.

National Museum, Bloemfontein

THE annual report of the National Museum at Bloemfontein for the year ended March 31, 1958, (pp. 22. Bloemfontein : National Museum, 1958) records the completion of ten new displays, including dioramas of vultures, pan-life (birds), *Uranocentrodon* (fossil amphibian) and *Aulacocephalodon* (fossil reptile). Several minor building extensions have been undertaken, although no start has yet been made on the two new wings for the Museum. Four members of the staff are studying at and writing theses for the Department of Physical Anthropology in the University of the Orange Free State at Bloemfontein, and various grants-in-aid enabled the Museum to undertake large-scale excavations at the Matjes River rock shelter.

Uptake and Translocation of Radioactive Phosphorus in Plants

G. N. THORNE (*Annals of Botany*, N.S., 32, 381 ; 1958) has investigated and discussed the factors which affect the uptake of radioactive phosphorus by leaves and its translocation in the plant. The rate of uptake of phosphorus-32 from solutions of labelled sodium dihydrogen phosphate sprayed on to one leaf of swedes (*Brassica napus*) or french beans (*Phaseolus vulgaris*) was rapid during the first few hours and fell to zero after four days. Phosphorus-32 was detected in the root after 3 hr. and continued to move out of the treated leaf for at least six days after application. A larger fraction of the applied phosphorus-32 was absorbed from repeated than from a single spraying. Swedes absorbed more phosphorus-32 from a single application to the lower surface than to the upper surface of the leaf. Doubling the concentration of the spray caused a small increase in the percentage of applied phosphorus-32 that was absorbed. Absorption by french bean leaves decreased slightly when the area sprayed with a constant amount of phosphorus-32 was doubled, and decreased with increasing age of leaf. Increasing the supply of phosphorus to the roots of swedes affected neither the initial rate nor the total uptake of phosphorus-32 by the leaves, but decreased the quantity of radiophosphorus that was translocated out of the treated leaf. Increasing the relative humidity of the air around the plants also increased uptake of phosphorus-32. Shading usually decreased uptake and always decreased translocation. Re-wetting the leaf to which the radiophosphorus had been applied, with water or sucrose solution, had variable effects.

Establishment of *Pythium* in Soils

R. BARTON has reported that, whereas species of *Pythium* can be isolated from cultivated soils by using susceptible host seedlings as bait, they could not be isolated from woodland, non-cultivated or very acid soils (*Trans. Brit. Mycol. Soc.*, 41, 207 ; 1958). The behaviour of inocula of *Pythium mamillatum* in a cultivated (native) soil, and in a woodland (alien) soil was assessed by means of the host test described. Maize meal added to the cultivated soil became colonized by *P. mamillatum* after only two days, indicating that, under these conditions, the parasite behaves as a saprophytic 'sugar fungus'. In the alien woodland soil, *P. mamillatum* did not colonize maize meal. After neutralization of this acid soil with lime, however, the fungus rapidly utilized the material. The parasite could not be grown in culture at the low *p*H value of the alien soil. The behaviour of vegetative hyphæ of *P. mamillatum* in these contrasting soils was studied by the glass-fibre tape technique. In native, cultivated soil, oospores and resting sporangia were formed abundantly, whereas in alien woodland soil these bodies were not produced. Thus, the inability of *Pythium* hyphæ to produce a resting phase may prevent long-term survival of the parasite in alien soils. This effect was shown to be due to low *p*H value of the soil, which may directly limit the normal life-cycle of *Pythium* in acid woodland soils.

Researches on Tropical Vegetation

THE scientific study of the rich and varied floras of tropical regions not only brings its own reward but also is of very real practical importance. The wise utilization of forested tropical lands is not merely something to be desired : it has been recognized as a problem of considerable urgency for many years, especially in regions of increasing population. A Unesco publication on humid tropics research entitled "Study of Tropical Vegetation" (written in both English and French. Pp. 226. H.M.S.O., 1958. 30*s*.), records the proceedings of a symposium held in Kandy, Ceylon, in 1956, and prepares the way for further investigations. Tropical forests, growing on soils of varying fertility, are the raw materials of agriculture, whether this be pursued piecemeal by small farmers or extensively by large plantation companies. Swamp and rain forests, though still of vast dimensions in some regions, are certainly not unlimited ; and those on soils of fair to good inherent fertility tend to become a shrinking asset, especially in areas which offer easy or reasonable accessibility. Where this is so, and in conjunction with a rapidly increasing population, the problems of adequate agricultural production become progressively more acute ; and research, combined with appropriate practical action, is seen to be essential. In the present report, some twenty-six technical papers contributed by specialists from thirteen countries give important indications as to what some of the basic problems are and how they may be tackled. In general, the coverage is what might be expected : tropical vegetation, in its many aspects, is described, mapped, illustrated and discussed, especially from the ecological point of view, and the relevant environmental factors analysed. The need for conservation under official auspices and for further study are strongly emphasized. The representative regional surveys and illustrations are specially attractive and valuable features of this volume.

Cocoa Conference 1957

UNDER the above title the Cocoa, Chocolate and Confectionery Alliance (11 Green Street, London, W.1) has published a comprehensive report (pp. xiv+326+35 plates. London : 1958. 63*s*.) giving the full texts of the papers presented at the international conference sponsored by the Alliance and held in London during September 10–12, 1957. The papers—nearly forty in number—are arranged under general headings corresponding to the sessions of the conference : commercial background ; developments in new cocoa-growing areas, planting materials and methods ; disease and pest control ; chemistry of cocoa fermentation ; preparation and quality ; and the cocoa tree in its environment. These titles show the scope of the conference, which brought together 282 delegates ranging from scientific workers in agriculture and food technology to representatives of industry and of government agencies. The majority of the participants were from different parts of the British Commonwealth, and two West African Governments—Ghana and Western Nigeria—were represented for the first time by Ministers. Delegates from different European countries and the United States were also present. This wide representation gave the conference its unique character. The report shows the efforts that have been, and are being, made by scientific workers in the laboratory and in the field to promote a branch of agriculture which is of vital importance to the economic stability of several Commonwealth—as well as other—territories overseas. The report will therefore be of value both to those actively concerned with the cocoa and allied industries and also to economists, agricultural scientists and others who are interested in the problems of the developing countries in Africa and elsewhere. Both these groups of readers will accept the report as an essential source book.

The Ciba Fellowship Trust

THE Ciba Fellowship Trust has been founded by Ciba Clayton, Ltd., Ciba Laboratories, Ltd., Ciba (A.R.L.), Ltd., and the Clayton Aniline Co., Ltd., for the purpose of improving and increasing the interchange of ideas between scientists in the United Kingdom and on the Continent. The trustees are Sir Arthur Vere Harvey, Lord Hives, and Sir Alexander Todd. The fellowships will be awarded by an advisory panel, the members of which are Sir Arthur Vere Harvey (chairman), Prof. A. J. Birch (University of Manchester), Prof. W. Bradley (University of Leeds), Dr. A. Brunner (Ciba, Ltd., Basle), Dr. E. Brunner (Clayton Aniline Co., Ltd., Manchester), Prof. D. H. Everett (University of Bristol), Prof. D. M. Newitt (Imperial College of Science and Technology, London), Dr. R. F. Webb (Ciba (A.R.L.), Ltd., Duxford). Several fellowships will be awarded for tenure during the academic year 1959–60 at Continental universities or institutions for research in chemistry, physics or some other allied scientific subject. They will be awarded to graduates of universities in the United Kingdom or the Republic of Ireland. The basic award for Fellows who wish to continue postdoctorate studies will be £800 per annum plus allowances. For candidates who have obtained a first degree in science and wish to undergo training in research, the basic award will be £500 per annum plus allowances. The total value of each fellowship will be determined by the advisory panel, and will be sufficient to cover the Fellow's living and other expenses (including fees and cost of travel) during the tenure of his fellowship, which will be for one year, renewable for a further one or three years. Applications should be made in duplicate on forms obtainable from the Secretary of the Ciba Fellowship Trust, Ciba (A.R.L.), Ltd., Duxford, Cambridge. The closing date for such applications is January 31, 1959.

C.S.I.R.O. Wool Research Laboratories

The three Wool Textile Research Laboratories of the Commonwealth Scientific and Industrial Research Organization (Australia) have been made divisions of the Organization. The Melbourne Laboratory becomes the Division of Protein Chemistry, the Sydney Laboratory the Division of Textile Physics, and the Geelong Laboratory the Division of Textile Industry. In future this group of divisions will be called the C.S.I.R.O. Wool Research Laboratories. These laboratories were established in 1949. The officer-in-charge of the Melbourne Laboratory, Dr. F. G. Lennox, becomes the chief of the Division of Protein Chemistry; the officer-in-charge of the Sydney Laboratory, Mr. V. D. Burgmann, becomes chief of the Division of Textile Physics; and the officer-in-charge of the Geelong Laboratory, Dr. M. Lipson, becomes chief of the Division of Textile Industry.

Annual Conference of Educational Associations

The forty-second annual conference of Educational Associations will be held in the College of Preceptors, 2 and 3 Bloomsbury Square, London, W.C.1, during December 30–January 2. Dr. B. E. Lawrence, chief education officer, Essex, will deliver the presidential address entitled "Partnership in Education" on the eve of the Conference in the assembly hall of the Institute of Education, University of London. During the Conference, and under the auspices of the School Nature Study Union and the Universities Federation for Animal Welfare, Miss F. R. Elwell, science producer, B.B.C. Television for Schools, will give a lecture on "Animals and Television" in the College of Preceptors on December 31 at 2.30 p.m. All meetings at the Conference are open free of charge and without tickets. Further information can be obtained from the Conference Secretary, 2 and 3 Bloomsbury Square, London, W.C.1.

Geographical Association Summer Schools

The Geographical Association is organizing two summer schools in 1959. The first, to be held in Spain during August 12–27, under the direction of Dr. M. J. Houston (Oxford), will deal with Mediterranean geography. On this course members will study the land-forms and vegetation climaxes on the northern and southern flanks of the central Pyrenees; contrasts in relief, vegetation and land use in the central cordillera of Spain (field excursions from Madrid); and distinctive types of land use and settlement in Valencia and Catalonia (field excursions from Valencia and Barcelona). Urban studies will be made in Madrid, Valencia and Barcelona. The second, to be in Switzerland during August 18 September 2, will consist of Alpine studies centred on Orsières in the Pennine Alps, near the Italian and French frontiers. It will be under the direction of Mr. R. C. Honeybone (London). Members will study the Alpine environment of the Drance River and its tributaries, and its physical and cultural relations with, to the north, the Rhône valley (Martigny and Sion) and, to the south, Val d'Aosta via Grand St. Bernard; a field excursion to study glacial features near Chamonix will be included in the programme. Members' field work and several of the field excursions will be done on foot, which will involve hill-walking and climbing but not rock-climbing. Further details and forms of application can be obtained from the Assistant Secretary, Geographical Association, c/o The Park Branch Library, Duke Street, Sheffield, 2.

University News: London

Dr. J. A. Laing, reader in the University of Bristol, has been appointed to the Courtauld chair of animal husbandry and veterinary hygiene tenable at the Royal Veterinary College.

The title of professor emeritus of plant physiology in the University has been conferred on Prof. F. G. Gregory on his resignation on December 31 from the chair of plant physiology at the Imperial College of Science and Technology, which he has held since 1937.

Announcements

The insignia of C.B.E. has been presented by the British Ambassador in Rome to Prof. Domenico Marotta. As director-general of the Istituto Superiore di Sanità in Rome, Prof. Marotta has an important position in chemical science and industry in Italy, and organized the meeting this year of the Eighth National Congress of the Italian Chemical Society jointly with the Society of Chemistry and Industry.

The Worshipful Company of Founders has awarded its medal in bronze to the following Liverymen of the Company to mark "their services to the Art and Mystery of Founding and to the Company": Dr. J. G. Pearce, director of the British Cast Iron Research Association; Dr. J. E. Hurst, managing director of Bradley and Foster, Ltd., Darlaston; Mr. C. C. Booth, director of Booth and Brooks, Ltd., Burnham-on-Crouch; and Mr. J. J. Sheehan, lately managing director of the Coneygrw Foundry, Ltd.

Mr. William Barr has been nominated by the Council for election as president of the Iron and Steel Institute for the 1959–1960 session. He will take office at the general meeting on May 6.

In February 1956 the National Metallurgical Research Laboratory of the Council of Scientific and Industrial Research, Jamshedpur, India, held a symposium on "Production, Properties and Application of Alloy and Special Steels". The forty-five papers contributed are now published (pp. vi+488. Jamshedpur: National Metallurgical Laboratory, 1958), and cover all the main aspects of the subject. Most of them are from Indian workers, but a dozen or so represent contributions from metallurgists in Europe and America.

THE NATIONAL CHEMICAL LABORATORY

THE National Chemical Laboratory, Teddington, of the Department of Scientific and Industrial Research, held a series of open days during October 21–24. In this article there is space to describe only some of the items on view.

Improved laboratory and semi-scale techniques for separating the rare earths have been developed, and considerable amounts of the individual oxides have been accumulated. Increased availability of these materials has prompted a search for new uses. A recent application of thulium was the subject of a very attractive display. When the pure oxide is irradiated in a high neutron flux, soft γ- and X-rays are emitted which can be used in engineering and medical radiography, and a number of interesting radiographs taken at the Atomic Energy Research Establishment, Harwell, were shown. The source unit consists of a small pellet of sintered thulia enclosed in an aluminium capsule.

The use of zone-refining for purifying materials used in researches on semiconductors, such as indium, tellurium, bismuth and aluminium, also attracted interest. The difficulties of following the course of purification by conventional analytical methods are considerable, and when possible, the movement of impurities is followed by introducing radioactive tracers; for example, the removal of silver from bismuth was effected by using radioactive silver as tracer. Other exhibits included the Department's collection of pure metals, and the recovery of valuable materials from industrial wastes.

In conventional processes for the extraction of uranium, it is necessary, after leaching the ore, to separate the barren solids from the uranium-bearing liquor; this liquid/solid separation represents a considerable percentage of the cost of extracting uranium. It has been found, with certain ores and with the correct degree of grinding, that satisfactory uranium extractions can be obtained by means of a limited contact between the aqueous leach pulp and the extracting solvent. This principle is employed in the disk contactor: the disks are wetted by the aqueous phase, and, as they rotate, a film of the aqueous solution is carried through the solvent, so effecting transfer of uranium.

Plastic standards for radiometric assay of uranium have been prepared by mixing 'Bakelite' moulding powder with pitchblende, the density of the standard being varied by addition of heavy fillers to the mixture before moulding. These standards, designed for use with prospectors' field ratemeters, possess the advantages that they are not liable to contamination or spillage and that they are not affected by changes in humidity or possible loss of radon.

Tests of the resistance of metals to corrosion and of the effectiveness of corrosion inhibitors are being made in water circulation systems at different speeds and temperatures of the water. The object of the work is to find means of reducing losses due to corrosion in industrial cooling systems.

*Cyclo*hexylamine carbonate has been applied by the Laboratory as a volatile corrosion inhibitor, and has given promising results in the protection of boilers and other steel equipment during shut-down periods.

The rate of oxidation of clean, pure iron is being measured by methods sensitive enough to detect the formation of less than one-tenth of a complete molecular layer of oxide per minute. The pressure in the apparatus can be controlled from less than 10^{-6} mm. mercury upwards.

Among various physico-chemical equipment for the examination of organic compounds was a simplified double-beam infra-red grating spectrometer using a 'Merton – National Physical Laboratory' replica as the dispersing element. The instrument is intended for chemical applications, both in analytical and structural diagnosis. The design allows solvent compensation to be achieved, and expansion of any part of the scale as required.

The stock of standard organic compounds available for distribution now includes fifty-five individual compounds. During the year, 395 samples were sent out to forty-five laboratories.

There is considerable interest at present in the development of materials of improved thermal stability for use as plastics, lubricants, hydraulic fluids, surface coatings, etc. A variety of organometallic compounds shows promise in this connexion, and work on this project has recently been initiated at the Laboratory. At present, attention is mainly directed to the boron-nitrogen and related systems.

Novel types of redox resins have recently been developed at the Laboratory. These resins are capable of undergoing true electron-exchange, that is to say, operating reversibly on an oxidation-reduction cycle. The new materials displayed were based on cellulose and polyvinyl alcohol and some of their potential applications were illustrated.

A knowledge of the molecular weights and molecular-weight distributions of commercially important polymers is of great importance to the polymer industry. A comprehensive survey of work in progress included the determination of the molecular weights and shapes of polymers by viscometry, osmometry, light-scattering photometry, and ultracentrifugation. Other exhibits showed the results of fractionation of polymers according to their chain-lengths, and the molecular weight distribution curves derived from these experimental studies.

Another facet of the work, namely, research on the synthesis of new types of ion-exchange resins and membranes, was also shown. Materials of this type are of great value in water treatment and extraction of valuable organic and inorganic substances from solution.

Microbial activities which have economic importance are also being studied. One extraordinary microbe needs no organic food—it lives on a simple diet of sulphur, mineral salts and air, and produces strong solutions of sulphuric acid. This organism is responsible for extensive damage to concrete structures such as water-cooling towers and sewage conduits. The use of sulphate-reducing bacteria to produce sulphur from sewage sludge and gypsum was illustrated. Demonstrations were given of the preservation of pure cultures of bacteria by freeze-drying; the bacteria can be revived after many years with unchanged properties. The number of strains held by the National Collection of Industrial Bacteria is about 1,100, from which 1,700 cultures were sent out during the past year.

FUNDAMENTAL RESEARCH IN SAFETY GLASS

THE Fundamental Research Laboratory of the Triplex Safety Glass Company at Holly Grange, Balsall Common, held an 'At Home' on November 14, to show the progress made since its official opening in December 1957. The main objective of the Laboratory is to establish the fundamental scientific background to safety glass manufacture and especially that of the toughened or tempered types which are produced by heat treatment. The work of the Laboratory falls roughly into four sections: toughened glass structure; physical chemistry; optics; and mechanical properties.

Work on the determination of the atomic structure of heat-treated glasses was shown in the X-ray, Electron-Microscopy and Thermodynamics Departments. Of special interest in connexion with X-ray investigations was a microdensitometer designed and built in the Laboratory.

Methods of producing safety glass by chemical means involving ion- and atom-exchange were shown in the Physical Chemistry Laboratory. Experimental low-temperature alloys for use as bus-bar material in glasses coated with gold film were also on view.

The work displayed in the optics section included stress measurements on toughened glass using Babinet and Sénarmont methods, together with interferometric methods of measuring the thickness of thin metallic films on glass. This latter was in connexion with the use of gold films, approximately 60 A. thick, which are used as heating elements on aircraft and other windscreens. Micro-hardness techniques to evaluate the surface properties of glass with special reference to abrasion resistance were also shown, together with apparatus for determining the light transmission of aircraft windscreens.

The results of investigations towards producing safety-glass components with less scatter in mechanical properties were on view in the Heat Treatment and Mechanical Properties Departments, where the application of schlieren methods for the study of the action of air jets used in the quenching process evoked much interest. The application of strain-gauge techniques to the evaluation of stress occurring in large glasses was also demonstrated.

THIRD INTERNATIONAL SEAWEED SYMPOSIUM

THE third International Seaweed Symposium was held in Galway, Ireland, during August 13–15, when some 220 scientists and industrialists from twenty-seven countries in Europe, Asia, Africa and the Americas attended. (The first and second Seaweed Symposia were reviewed in *Nature*, 170, 478; 1952; and 176, 1106; 1955.) The symposium was opened by Mr. Seán Lemass, Minister for Industry and Commerce, who welcomed the delegates to Ireland.

Our knowledge of the physical structure of the cell-wall of many algae has been greatly increased within recent years by new techniques such as polarization microscopy, electron microscopy and X-ray diffraction analysis, and these were reviewed by Prof. R. D. Preston (England). The chemistry of the polysaccharides of the brown, red and green algae was covered by Prof. E. L. Hirst (Scotland), and Dr. H. M. Ulrich (Austria) dealt specifically with alginic acid and its derivatives both from the chemical and industrial points of view.

Nine papers were devoted to the chemistry of the carbohydrates, proteins and other constituents of the red algae. Low molecular compounds were discussed by Mr. B. Wickberg (Sweden). Further interesting glycosides have recently been isolated; for example, '*iso*floridoside' is a mixture of diastereoisomers (1-O-α-D-galactopyranosyl D- and L-glycerol), while O-α-D-galactopyranosyl (1 → 6)-O-β-D-galactopyranosyl (1 → 1)-glycerol, which occurs in wheat flour lipids, has been found in two red algae. Dr. J. R. Turvey (Wales) dealt with the polysaccharides of *Porphyra umbilicalis*, which include a galactan sulphate, floridean starch, mannan and xylan; the galactan sulphate contains D-galactose, 6-O-methyl-D-galactose and 3 : 6-anhydro-D-galactose. 3 : 6-Anhydro-galactose is now a common constituent of red algal galactans. 6-O-Methyl D-galactose has been isolated from several *Porphyra* species, and Dr. J. C. Su (Formosa) reported its presence in *P. crispata*. The mucilage of *Gloiopeltis furcata* appears to be composed chiefly of agarobiose units, as in the case of the main polysaccharide ('agarose') of agar-agar. Prof. P. S. O'Colla (Ireland) discussed the constitution of the mucilage from *Laurencia pinnatafida*, which contains galactose, xylose, galacturonic acid and sulphate; the branched structure contains a 1 : 3-linked galactan backbone. A somewhat similar structure has been assigned to the gelatinous polysaccharide of *Furcellaria fastigiata*. Dr. E. G. Young (Canada) pointed out the many difficulties encountered in examining the amino-acids, peptides and proteins of *Chondrus crispus*; about 20–30 per cent of the protein nitrogen could not be solubilized, but the distribution of amino-acids in this insoluble protein was similar to other algal proteins; 80 per cent of the total nitrogen extracted was dialysable. Dr. Young also discussed the stability of carragheenin in dried *C. crispus*, which is of considerable importance to the seaweed industry; intrinsic viscosity and gel strength decreased markedly after storing the weed at 4°, 10° and 20° C. for two years, indicating degradation of carragheenin in the plant. Mr. M. O. Reachtaire (Ireland) read a paper on phycoerythrin and phycocyanin, and the absorption spectra and structure of these chromoproteins were discussed. Dr. C. Ó hEocha (Ireland) described the occurrence and distribution among a number of red algae, particularly in the Rhodomelaceae, of four water-soluble fluorescent substances; these were extracted, separated by chromatography, and characterized by their absorption spectra. One compound from *Laurencia pinnatafida* was obtained in crystalline form and its probable structure determined.

The polysaccharides of *Acrosiphonia centralis*, a green alga closely related morphologically to *Cladophora rupestris*, were reported by Dr. E. Percival (Scotland); partial hydrolysis of a sulphated polyuronide gave chiefly glucose, xylose, rhamnose and oligouronic acids composed mainly of rhamnose and glucuronic acid, and comparisons were made with the polysaccharides from *C. rupestris* and *Ulva lactuca*. Present evidence suggests that the green algae are the most complex from the chemical point of view.

Several communications were devoted to alginic acid and the alginates. The seventy-fifth anniversary of its discovery was marked by a short biographical sketch of E. C. C. Stanford by Dr. T. Dillon (Ireland). The seasonal variation in the alginic acid content of *Ascophyllum nodosum* was discussed by Mr. D. T. Flood (Ireland), while the effect of species, habitat, pre-treatment of the seaweed and isolation procedures on the viscosity of alginate solutions was covered by Mr. A. Haug (Norway). Methods for determining alginic acid were reviewed by Mr. M. F. Van der Lande (France), and details of the copper acetate and a new potentiometric titration method were given. The precipitation of sodium alginates of different degrees of polymerization by salts of lead, calcium, nickel and manganese was shown by Mr. R. H. McDowell (England) to be a complex problem and highly dependent on alginate concentration. The birefringent properties of alginate and carragheenate with colloid cations, for example polyglucosamine, were demonstrated by Dr. L. Langmaack (Germany), and there is a possibility that the phenomenon known as *Symplexionotropie* may be responsible for the formation of ordered structures in the plant *in vivo*. Dilute acid extracts of some brown algae contain phenolic reducing compounds known as 'fucosan', which are located in the physodes and are responsible for the brown colour formed in alkaline seaweed extracts; the fucosan content of *A. nodosum* was reviewed by Mr. A. Haug (Norway), and the influence of habitat on this and other constituents was discussed by Mr. B. Larsen (Norway), who also gave details of the influence of season, habitat and age of tissue on the niacin content of brown algae. The minimum number of plants required to give a representative sample for chemical analysis has been a vexed question for many years; in a paper on the statistical analysis of a large number of *Laminaria cloustoni*, Mr. F. T. Walker (Scotland) suggested 120 plants grouped according to haptera levels.

Both chemical and enzymic methods for removing sulphate groups from carbohydrates are of extreme importance in the elucidation of structure of the many algal polysaccharide sulphuric esters, and these were reviewed by Dr. P. F. Lloyd (Wales), who went on to describe the action of the sulphatases of *Patella vulgata* on fucoidin, chondroitin sulphate and keratosulphate. Further work in this field is awaited with interest. The use of the mass spectrometer in carbohydrate problems was outlined by Mr. P. A. Finan (Scotland); the potentialities of this ionization technique are immense in structural and conformational studies. Dr. C. C. Burt (Scotland) described the results of animal experiments with sodium laminarin sulphate as a blood anticoagulant; in rabbits and dogs, single doses of 20 mgm. per kgm. were well tolerated, but daily injections over 1–2 weeks produced toxic symptoms; the cause of this toxicity was discussed.

The occurrence and utilization of algae in the Caribbean and Morocco were discussed by Mr. W. D. Richardson (British West Indies) and Mr. G. Apikian (Morocco), respectively. The value of two New Zealand species, *Pachymenia himantophora* and *Durvillea antarctica*, as a fertilizer was assessed in a paper read by Mr. M. O. Reachtaire (Ireland). The interesting work being carried out in Norway on the use of seaweed meal as a supplement in animal feeding-stuffs was reported at the last symposium; Prof. J. Höie and Mr. A. Jensen (Norway) described further trials with chicks, hens, rats and sheep. The attitude of industry towards the research institute was assessed by Mr. E. Booth (Scotland) with particular reference to seaweed.

Critical observations on the taxonomy, ecology, growth and development of single species of marine algae formed the basis of several papers presented in the botanical sessions of the symposium. Dr. P. S. Dixon (England) showed that season and environment cause considerable morphological variation in *Pterocladia pinnata*, with the result that there has been taxonomic confusion in this species. Considerable variation was also noted by Dr. G. T. Boalch (England) in pure cultures of *Ectocarpus confervoides*, grown under different physiological conditions. The culture, growth and differentiation of *Caulerpa prolifera* were discussed by Prof. W. P. Jacobs (United States), who carried out experimental work on this species in the Naples Marine Laboratories.

Little has been reported on the effects of growth substances on the growth and development of marine algae. Dr. L. Provasoli (United States) found that, in bacteria-free cultures of *Ulva lactuca* (in sea-water media enriched with vitamins), the initiation of new germlings and the length of atypical filaments were increased by the combination of kinetin and indolacetic acid. Conspicuous elongation of the filaments was promoted by the addition of gibberellins to the kinetin–indolacetic acid combination.

An interesting account of *Monostroma* culture in Japan was given by Prof. T. Segi (Japan). It was shown how the results of a study of zoospore development in this species were of value to those concerned with its commercial culture. It is used for food as 'Aonori'.

The effects of environment on the development of *Fucus vesiculosus*, growing on an exposed shore and in an enclosed bay, were explained by Prof. W. R. Müller-Stoll (Germany).

Mr. H. T. Powell (Scotland) proposed that of the fifteen or so *Fucus* species currently recognized in various parts of the world, only five (or six) should be accorded specific rank. The species are *Fucus serratus* L., *F. vesiculosus* L., *F. ceranoides* L. emend., *F. spiralis* L. emend. (or *F. sherardii* Stackhouse emend., still being investigated), *F. distichus* L. emend. Powell, and perhaps *F. virsoides* J. Agardh.

Studies of the growth of *Macrocystis pyrifera* at various depths in the sea were reported by Prof. F. T. Haxo (United States), who has developed techniques and instruments which should prove useful in similar studies of other attached seaweeds.

Mr. B. Grenager (Norway) explained how he was able to predict the distribution of *Laminaria digitata* f. *stenophylla* and *Ascophyllum nodosum* in unknown areas on the Norwegian coast, by a study of charts only. The predictions were later substantiated by field surveys.

Nitrogen fixation by terrestrial blue-green algae is well known, but as Dr. M. B. Allen (United States) pointed out, little is known of nitrogen fixation by marine organisms. Dr. Allen gave an account of how she is growing pure cultures of freshwater nitrogen-fixing, blue-green algae under saline conditions, and reported the effect of this on their capacity for nitrogen fixation.

Dr. M. R. Droop (Scotland) discussed evidence for and against the view that vitamin B_{12} may become a limiting nutrient for phytoplankton populations in the sea. The mass culture of marine phytoplankton was reviewed by Dr. G. E. Fogg (England), who concluded that it was unlikely to become a practical proposition, at least until harvesting difficulties could be overcome.

Dr. J. W. Kanwisher (United States) reported on a new method of continuous oxygen recording which has been used for measuring the photosynthetic and respiratory capacity of several intertidal algae.

Details of a method of physode estimation were given by Dr. E. Baardseth (Norway), who found that the percentage physode volume varied from species to species and in *Ascophyllum*, with variation in salinity and habitat.

Prof. H. A. von Stosch (Germany) discussed similarities between the leucosin of diatoms and chrysomonads and the laminarin of Phaeophyta. He gave evidence to support the conclusion that these substances are closely related.

The main symposium was followed by a single-day symposium on "Intertidal Ecology".

The time available for discussion following each paper was very limited, but there were ample opportunities for private discussion at the various shore-collecting excursions and social functions run in connexion with the symposium. It was agreed that the complete text of the papers presented should not be published. The fourth International Seaweed Symposium is to be held in France in September, 1961, and an Advisory Committee consisting of Prof. T. Braarud (Norway), Dr. T. Dillon (Ireland), Prof. T. Levring (Sweden), Dr. A. D. de Virville (France), Dr. F. N. Woodward (Great Britain) and Dr. E. G. Young (Canada) was appointed to assist the French National Committee in drawing up a programme.

W. D. RICHARDSON
E. T. DEWAR

INTERNATIONAL CONFERENCE ON SCIENTIFIC MEASUREMENTS

AN international conference on the theoretical and practical problems involved in making scientific measurements was held in Budapest during November 24–29. Part of the conference was held in the building which was formerly the Stock Exchange but is now the home of the engineering societies and is re-named Technika Háza. The other meetings were held in the Rózsa Ferenc House of Culture. Some 250 foreign and 460 Hungarian scientists took part in the conference, and representatives came from twenty-three countries. Academies of science in a number of countries, including France, Italy and Sweden, either sent representatives or gave their official support to the conference.

Some 160 papers were read, 127 of them by non-Hungarian scientists. The papers were divided into a number of sections with the following titles: mechanical and optical, electrical and electronic, thermal, physico-chemical and nuclear-physical. There were also papers on the economics of instrument production, and an informal discussion was held between the university teachers present to discuss student courses for measuring techniques and instrument-making. Though there were many papers of considerable individual merit, one difficulty emerged during the conference, namely, that in some sections the papers were too diverse in character to form a coherent whole. Summaries of most of the papers were published in two booklets, mostly in the German language, though some were given in English, French or Russian.

The Hungarian Chamber of Commerce arranged an exhibition of Hungarian scientific instruments in the Technika Háza. The well-known skill of Hungarians in arranging exhibitions was clearly shown here. Though there were gaps in the range of instruments exhibited, the level of instrument technology in the fields covered appeared to be high.

This conference was called by three organizations acting jointly, one Hungarian, one in the Soviet Union and one in Poland. The Presiding Council hopes to prepare a further conference, probably in 1961, and to enlarge the national representation on the committee which will organize it.

Visits to scientific institutes in the Eötvös Lorand and the Technical Universities and in the Academy of Sciences were arranged. There was also a social programme which included visits to the opera, theatre and cinema. Those attending the conference were very conscious of their debt to the members of the staff of the Hungarian Federation of Scientific Societies for the care which they took in ensuring the comfort and the convenience of visitors.

W. A. WOOSTER

THE FUTURE OF ANTARCTICA

"THAT a new era in Antarctica indeed is opening needs clearer recognition. Suddenly Antarctica now has applied to it the resources, the techniques and the wealth of experience from no less difficult operations in the Arctic. The United States pre-eminently, and Russia not far behind, both possess and feel it expedient now for the first time to use great resources in Antarctica on a scale without precedent. Their northern experience is immense. Yet great resources of men and materials are not deployed by even the very powerful without strong reasons."

"Political stability in Antarctica in the next few years is certainly improbable. The post-war realignment of the nations in terms of modern power and resources is now in process of extending to Antarctica. . . . Now is the time for realism and re-appraisal by the sovereign states of Antarctica."

These quotations from the published version* of the lectures delivered by Dr. G. C. L. Bertram while he was William Evans visiting professor in the University of Otago in 1957 indicate well the nature of his theme. Dr. Bertram, who was director of the Scott Polar Research Institute at Cambridge during 1949–57, speaks with authority about Antarctica, and in this thought-provoking essay he speaks with evident concern. He recognizes and discusses five motives that may underlie rational activity in Antarctica—the adventurous, economic, scientific, political and strategic motives, and from his discussion there emerges a picture of the present situation in which the last two named are dominant, a situation in strong contrast to that which obtained in the first twenty years of this century when British expeditions dominated the Antarctic scene and interest was primarily adventurous and secondarily scientific. Dr. Bertram examines the probable motivation of the twelve nations that may be said to-day to have Antarctic 'aspirations' or 'interests'. Five of these—Australia, France, Great Britain, New Zealand and Norway—lay formal claim to sectors of Antarctic territory which cover about four-fifths of the continent. The sovereignty of these five mutually recognizing Powers is, however, not admitted by the United States and the U.S.S.R., the two Powers deploying greatest resources in the Antarctic, and is openly flouted by others. Time, Dr. Bertram insists, is not upon the side of the five, and their position is not helped by their comparative grave weakness in shipping suitable for the maintenance of their Antarctic interests. "Not one of the five," he remarks, "has the full manœuvrability and appearance of power only to be given by the possession of a genuine ice-breaker. On the other hand, Russia, the United States and Argentine have admirable such vessels, and even Chile has building a ship superior to anything possessed or yet being built by the five. Our grandfathers must turn in their graves at this astonishing change in maritime power and forethought and at the depths to which the British Commonwealth has sunk." There is an over-riding need, Dr. Bertram thinks, for consultation by the five, and first and especially by the three Commonwealth countries, and a re-appraisal leading to a constructive plan. "When the passage of time may seem to give advantage to the rival or adversary, then it is often rationally expedient to seize the initiative."

Dr. Bertram considers some of the theoretical possibilities for the future political evolution of Antarctica, namely, recognition of existing claims (and here he notes how much this would be aided if the United States even now were to lay claim, as it has excellent reason for doing, to the remaining unclaimed Pacific sector); sale of Antarctic territory; condominium, possibly under the United Nations Organization; partition into territories each administered by members of the United Nations in trust; and finally, what he calls the "functional approach" whereby the powers of existing international and technical organizations, such as the International Civil Aviation Authority or the World Meteorological Organization, should be recognized as providing the effective authority within their spheres of activity. This functional approach is attractive, but whatever the mode of evolution favoured, Dr. Bertram is clearly right in calling for some immediate and realistic thinking, both in Britain and in the Commonwealth, concerning our Antarctic aspirations and responsibilities.

DAVID L. LINTON

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* Antarctica Today and Tomorrow. By Prof. G. C. L. Bertram. Pp. ii+28. (Cambridge: At the University Press; Melbourne: Melbourne University Press, 1958.) 5s. net.

ROTHAMSTED EXPERIMENTAL STATION

REPORT FOR 1957

EVERY year, when reading the annual report of the Rothamsted Experimental Station*, one is impressed anew by the scope of the work undertaken by Britain's oldest agricultural research centre. Not only British but Commonwealth problems receive regular attention, a fact well shown by the list of overseas visits and secondments of staff for the purposes of specialist consultation or investigation. The present report is the fiftieth of the series, and a valuable inclusion is a summary index covering this period. It is, indeed, a concise history of the development of Rothamsted in the present century.

Comprising, as it does, the work of fifteen departments as well as such activities as soil surveys at home and abroad, it is not possible for any single reviewer to discuss critically all the varied information contained in the report. The main lines along which research is proceeding may, however, be indicated.

In the Physics Department work has continued on the structure and properties of soil, particularly clays. Studies on these suggest that, when they are wetted slowly, subsequent flooding does not produce the slaking effect that it has on a dry clay and that the shattering effect of entrapped air seems to be very slight. The practical effect of this seems to be that, in a saturated atmosphere, the slaking action of rain on dry field soil is confined to the surface, since the diffusion of water vapour downwards ahead of the liquid wetting front permits a controlled swelling of the clay without disruption. Other investigations have dealt with temperature and water relations in soil and with crop environment with particular emphasis, during the period under review, on spring wheat. It has been shown that short-period fluctuations in the rate of water uptake by wheat follow closely the changes in sunlight intensity.

The Chemistry Department has continued its experiments on the use of fertilizers and it is clear that seasonal variations in crop response to nitrogen are so large that it is not yet possible to make practical recommendations to the farmer with the certainty that he would like. This is not surprising since the maximum profit from any particular crop does not depend on one factor alone. One interesting finding was that heavy dressings of calcium nitrate damaged germination and early growth of all crops, while under the same conditions an equivalent amount of ammonium sulphate was harmless. Alternatives to superphosphate have been tested, but none so far has proved superior to this well-tried substance, a fact, surely, that would have gratified Rothamsted's founders. Work has continued in the Pedology Department on the mineralogy of soil components, the determination of which is of great help to the Soil Survey. Materials from Britain and from abroad have been studied, and a number of unusual minerals identified.

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* Rothamsted Experimental Station (Lawes Agricultural Trust). Report for 1957 (With 50-Year Index, 1908–57). Pp. 316. (Harpenden: Rothamsted Experimental Station, 1958.) 10s.

The nitrogen cycle and the ecology of soil micro-organisms remain the two major interests of the Soil Microbiology Department. The relationship between *Rhizobium trifolii* and its phage has been studied, and changes in the latter have been noted during storage in artificial soil. A fungistatic action by certain aerobic spore-forming bacteria has been demonstrated in all soils examined except those with a strong acid reaction, and it is suggested that such bacteria may be responsible for fungistasis in natural soil in the field. Other investigations have concerned the bacterial decomposition of herbicides and cellulose.

Various aspects of plant nutrition and growth have continued to interest the Botany Department, particularly the effect of nutrients on root and leaf growth. The known relation of leaf area to crop yields makes such studies of considerable practical interest. The effects of nitrogen, phosphorus and potassium on leaf area have been examined, as was that of gibberellic acid. The effect of this last was one of increasing the leaf area rather than the photosynthetic activity of the plant. A foliar application of gibberellic acid to potato increased leaf area and crop yield but caused some malformation of the tubers.

Plant enzymes engaged the attention of the Biochemistry Department, and an article on "Bracken Thiaminase" by R. H. Kenten is included in the report. This study has not yet produced results of practical application in bracken eradication, but a useful and necessary start has been made in acquiring the basic knowledge essential to a solution of this most important agricultural problem.

The contribution of Rothamsted to our knowledge of plant viruses is universally appreciated and needs no advertisement. The Plant Pathology Department is as active as ever in this field and much detailed and fundamental research continues. Electron microscopy has added much to our knowledge of viruses, but advances in technique are needed for this tool to be fully exploited. Possibilities in this direction are under continuous examination, and the published work of the Department is proof of the progress made in this very critical matter. In addition to the better-known plant viruses, those of cereals and grasses have received attention. Yellow dwarf virus is increasing in cereal crops in Britain, but more needs to be known concerning its effect on yield. Results recorded here suggest that this is more severe on oats than on wheat and barley. The susceptibility of various grasses to infection by cereal viruses and the identification of their vectors have also been studied.

Work on eelworms of economic importance and their predators has been the concern of the Nematology Department, while the Insecticides and Fungicides Department has continued the study of the pyrethrins and the effect of environmental conditions on the toxicity of various insecticides and fungicides.

The Entomology Department is working on various aspects of the biology and ecology of insect pests, in particular, aphids, frit fly, gall midges and the wheat bulb fly. The study of the behaviour, physiology, nutrition and the diseases of bees has been continued by the staff of the Bee Department.

Statistics have always figured largely in the work of Rothamsted, and the installation of an electronic computer has increased both the range and the volume of the work of the Statistics Department. In addition to work on the Station's own experimental data, help has been given to outside institutions in planning experiments and analysing results.

The report includes a list of the field experiments now in progress on the Rothamsted and Woburn farms and an account of the year's progress in the Soil Survey of England and Wales. Accompanying the article on bracken thiaminase already mentioned are papers by Mary D. Glynne and G. A. Salt on "Eyespot of Wheat and Barley" and by R. G. Warren on "The Residual Effects of the Manuring and Cropping Treatments in the Agdell Rotation Experiment".

The list of contributions to scientific journals made during the year with which the report ends bears evidence of the industry with which current problems are being investigated at Rothamsted and are a tribute to all concerned. J. H. WESTERN

EAST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANIZATION

REPORT FOR 1957

THE East African Agriculture and Forestry Research Organization is an inter-territorial research organization administered by, and forming part of, the East Africa High Commission. It is jointly financed by the three East Africa Territories of Kenya, Tanganyika and Uganda, the Protectorate of Zanzibar and the United Kingdom Government through the Colonial Development and Welfare Fund. The principal functions are to undertake long-term research work on behalf of the Territorial Departments of Agriculture and Forestry or to investigate problems which require highly specialized equipment or research officers. The present report (East Africa High Commission: East African Agriculture and Forestry Research Organization. Record of Research for the period 1st July, 1956, to 31st December, 1957. Pp. vii+112. (Nairobi: Government Printer, 1958.) Sh. 3/50) describes examples of each of these types of work and contains much of interest to all those concerned with agriculture and forestry in the tropics. The Physics Division in collaboration with the plant physiologist has continued to investigate the water relationships of plants and soils, and in particular have been concerned with problems associated with the most economical use of available water. This work also involves calculation of the amount of water which crops use from week to week, from simple meteorological and basic soil data. The prediction of crop responses of the soil and the build-up of nitrates in the soil due to decomposition of soil humus are two important aspects of the work of the Chemistry Division. It has now been shown that soil humus may be divided into two parts. One part is held by the soil and is resistant to decomposition even if the soil is kept warm and moist. The other much smaller part is in the soil solution and oxidizes rapidly under these conditions. Humus comes into solution when a dry soil is wetted, and the drier the soil before wetting the greater the amount of organic matter coming into solution. Thus, nitrates are only produced in the soil in appreciable quantities during the first rains after the dry season, and if leaching occurs there is not likely to be appreciable production of new nitrate later on. This emphasizes the need to get crops established as early as possible in the wet season. The Plant Pathology Division, starting with Central American varieties of maize, has successfully completed a breeding programme to give varieties resistant to tropical American maize rust, *Puccinia polysora*, a disease which first occurred in East Africa in 1952. Forestry investigations are mainly concerned with problems in the drier areas of East Africa. The Animal Nutrition Division has made extensive analyses of the main organic components of several local grasses at different times of the year, and the apparent digestibility of these grasses has been compared with those from temperate regions. Collecting of botanical specimens has actively continued and the services of the herbarium for identification of specimens has been in great demand from neighbouring territories.

ELECTRON RESONANCE STUDY OF THE RADICALS PRODUCED BY CONTROLLED POTENTIAL ELECTROLYSIS OF AROMATIC SUBSTANCES

By D. E. G. AUSTEN, Dr. P. H. GIVEN, Dr. D. J. E. INGRAM and M. E. PEOVER

British Coal Utilisation Research Association, Leatherhead, Surrey
and
Department of Electronics, University of Southampton

THE negative ions formed by electron transfer from sodium metal to hydrocarbon molecules in tetrahydrofuran solution have received much attention in the past year or so, and recently studies have been extended to the similar ions formed in the same way by carbonyl, nitro and cyano derivatives[1]. The same radical-ions have been postulated as the primary products of the polarographic reduction of aromatic hydrocarbons in dioxan-water[2] and of aromatic carbonyl compounds in the non-proton-active solvent dimethylformamide[3]. These inferences from polarographic behaviour have not hitherto been supported by any direct demonstration that the ions are indeed present. We wish to report such a demonstration, obtained by measuring the electron resonance signal given by solutions electrolysed under the polarographic conditions.

Anthracene, benzophenone and anthraquinone have been electrolysed (the apparatus and method are described in ref. 4) in 0·1 *N* tetraethylammonium iodide in dimethylformamide, using a stirred mercury cathode the potential of which was maintained at a value corresponding to the top of the first wave of each substance[4,5]. Under these conditions the polarographic evidence indicates that the paramagnetic mononegative ions should be formed (Fig. 1):

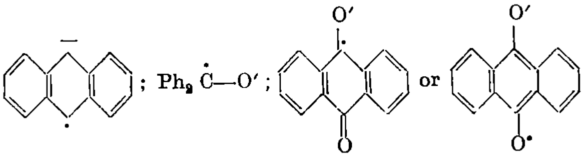

Fig. 1

At intervals during the electrolyses, samples were withdrawn under oxygen-free nitrogen into tubes of a size to fit the resonant cavity exactly. The tubes were immediately chilled in liquid nitrogen and sealed, and the signal was measured, a few hours later, in a 3-cm. wave-length electron resonance spectrometer. This employed an H_{014} rectangular cavity cooled to liquid-oxygen temperatures, and obtained high sensitivity by magnetic field modulation at 100 Kc./s., and phase-sensitive detection[6]. The

Table 1. Details of Reaction Conditions and the Products

Substance	$-E_{1/2}$ (volt) versus mercury pool	Controlled potential (volt)	n*	Concentration of solution (mM)	Max. concentration free radicals (mM)	Nature of product	Line-width (gauss)	g-value (± 0·001)
Anthracene	1·41, 1·88	− 1·55	2	40·1	0·31	Dihydroanthracene	18	2·005
		− 1·55	—	28·1	0·30			
Benzophenone	1·22, 1·47	− 1·3	2	33·0	0·83	Benzhydrol	19	—
Anthraquinone	0·33, 0·90	− 0·5	1	12·7	18	Equimol. mixture anthraquinone + 9 : 10-diacetoxy-anthracene†	11	2·007

* n = Faradays of electricity/mole of reducible substance. † Product was acetylated.

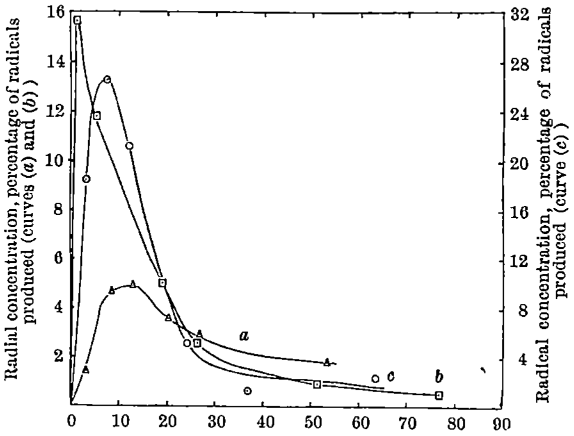

Fig. 2. Concentration of free-radical-ions as a function of degree of reduction: (*a*), Anthracene, 7·14 gm./l. (△); (*b*) anthracene, 5 gm./l. (▣); (*c*) benzophenone, 6 gm./l. (⊙)

concentrations of free radical were calculated by comparing the integrated signal strengths with those from standard samples, and the absolute accuracy of the results is estimated at about ± 20 per cent. The number of radicals produced by electrolysis was calculated from the quantity of electricity passed, which was measured with a coulometer.

Details of the experiments are shown in Table 1. Appreciable concentrations of radicals were found in the solutions of all three substances. Since the measurements were all made on materials in the solid state, considerable anisotropic dipolar broadening was present and no hyperfine structure was observed. The magnitudes of the line widths were found to vary somewhat with dilution, confirming the fact that dipolar interaction was the main source of broadening. It is seen that the anthraquinone radical-ion has a *g*-value appreciably shifted from that of the free spin (2·0023), and this suggests that there is some localization of the unpaired electron in this case.

The results are shown in Fig. 2, where the concentration of radicals in each sample is expressed as a percentage of the total number produced at the cathode up to the time of withdrawal of the sample (it should be noted that for anthracene and benzophenone this fraction could not exceed 50 per cent since, according to the mechanism to be described, all the molecules of aromatic substance are on the average reduced twice). 'Total reaction' signifies the passage of 1 or 2 Faradays per mole, as indicated in Table 1.

Anthracene and benzophenone gave the dihydro products in good yield although the controlled potential was less than that required for two-electron reduction; there was no evidence of dimerization. The curves show that the radicals produced from these substances are consumed fairly rapidly. It has been shown[7] that disproportionation of hydrocarbon mononegative ions:

$$2\,R' \rightleftharpoons R + R''$$

is energetically not feasible. We therefore suggest the following mechanism to account for the observations (Fig. 3):

$$\begin{array}{rll} R + \varepsilon & = R' & (1) \\ R' + \text{solvent} & = R\text{H}\cdot & (2) \\ \text{either } R\text{H}\cdot + R' & = R\text{H}' + R & (3a) \\ \text{or } R\text{H}\cdot + \varepsilon & = R\text{H}' & (3b) \end{array}$$

Fig. 3

Reactions 2 and 3*a* occur in the bulk of the liquid; the first of these must require activation and therefore be slow (that this is the mechanism of proton addition has been established[8] already). Hoijtink *et al.*[2] have shown that the radicals RH· derived from hydrocarbons always have higher electron affinities than the parent hydrocarbon molecules; moreover, electron-transfer reactions of the type of 3*a* are known to be rapid and not to require activation (for example, refs. 9, 10). Reaction 3*a* is therefore likely to be more important than 3*b*, and the RH· radicals will not make any significant contribution to the total concentration of radicals measured. The molecule R produced in 3*a* returns to the electrode and is reduced again. The difference in the results obtained in the two experiments with anthracene is probably due mainly to differences of temperature; heat is evolved during the electrolysis and an appreciable rise in temperature occurs in the early stages of reduction. Since the initial concentrations were different and moreover cells having cathodes of different area were used, the temperature history would have been different in the two experiments. If the temperature could be controlled, it would be possible to deduce the rate of protonation of R' from the results of experiments of this kind. The solvent used contained a small amount of water as impurity, but its molar concentration was less than one-fifth of that of the organic solutes, so that it cannot have made much contribution to the protonation by reaction 2.

The behaviour of anthraquinone is quite different from that of the other substances. Only 1 Faraday per mole was consumed. The concentrations of radicals measured in six samples collected during the electrolysis were very high; the values obtained were in fact all more than 100 per cent of those calculated from the initial concentration and the quantity of electricity passed, and rose from 109 to 150 per cent. These errors are mostly outside the expected limits of accuracy of the measurements and are difficult to account for. Some samples of the electrolysed solution were kept at room temperature for 6 hr. before measurement, and the observed concentrations of radicals were an appreciable fraction (20–40 per cent) of those obtained for the samples preserved in liquid nitrogen. This confirms that the rate of decay of radical concentration is small, and justifies the view

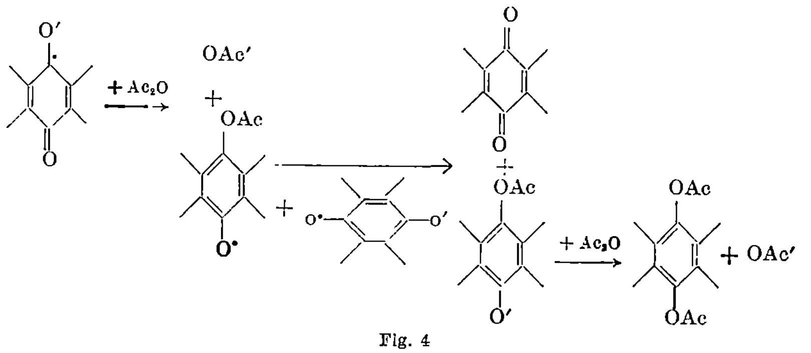

Fig. 4

that the fractional concentration is near 100 per cent throughout the electrolysis and that no protonation occurs. In order to facilitate identification of the product, acetic anhydride was added at the end of the electrolysis. The sequence of reactions shown in Fig. 4 can account for the result (that is, two moles free-radical-ion giving one mole each of the quinone and 9 : 10-diacetoxyanthracene).

Although the anthraquinone radical was stable enough to be examined at room temperature, it was not possible to observe any hyperfine structure, owing to lack of homogeneity in the magnetic field under the conditions that were used. The paramagnetic resonance spectrum of the 'semiquinone' of anthraquinone has been reported previously[11]; hyperfine structure was resolved and a *g*-value of 2·00403 quoted. However, it is not clear whether the species studied was the semiquinone itself or the semiquinone ion or the undissociated sodium salt. (For various views on the species of radical in the case of benzoquinone see refs. 12, 13.)

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A CORRELATION BETWEEN SULPHUR CONTENT AND NET DIETARY-PROTEIN VALUE

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WITH the work of Willcock and Hopkins[1] and Osborne[2] the concept was established that the nutritive value of proteins could be interpreted in terms of amino-acid composition, or, in the light of more recent work[3], in terms of their content of essential amino-acids, and might therefore be estimated by chemical means.

Complete amino-acid analysis has much to commend it theoretically, but the methods available are frequently less accurate, more time-consuming and more expensive than the biological measurements used to monitor them. Furthermore, the most accurate amino-acid analysis of a protein does not necessarily provide an unequivocal basis for determining its nutritive value, or even the amino-acid limiting its value.

Attention has recently been focused on specific indispensable amino-acids in proteins. Of the chemical methods in current use, the measurement of 'available lysine' in protein concentrates, used in animal feeding, is most promising[4], but from inspection of the composition of human diets, containing proteins from many sources, the sulphur-containing amino-acids, methionine and cysteine together, rather than lysine, appear to be limiting. Where this is not the case (as, for example, in white flour[3]), they are frequently the second factor restricting nitrogen retention.

Rose[5] has remarked that "the diets consumed by a large part of the human race are known to be relatively low in methionine". Experimental evidence in support of this contention is found in the work of Miller and Dema[6]; 70 per cent of the human diets, assayed by biological methods, were shown to be effectively supplemented with methionine.

It therefore seemed to us that the determination of the total sulphur content of mixed diets might provide a simple chemical method for estimating the nutritive value of proteins.

A preliminary examination of biological data, taken from Block and Mitchell[3], and chemical figures from the food tables of McCance and Widdowson[7], relating to some twenty-five foodstuffs, revealed a correlation between their sulphur content and net protein value. (The correlation coefficient was 0·913; $P < 0{\cdot}001$.) By common usage, net protein value (= biological value × digestibility × per cent crude protein) is determined on animals fed semi-synthetic diets containing the test protein at 10 per cent level. In the present experiments, the biological measurements were made by the method of Miller and Bender[8], using freeze-dried human diets from various parts of the world. To avoid confusion in terminology, since these materials were fed without any artificial adjustment in composition, net protein value is here termed net dietary-protein value[9], and the diet is evaluated in terms of reference protein[10].

Total sulphur was determined by combustion of the material in a Berthelot–Mahler bomb, precipitation of the sulphuric acid so formed with benzidene hydro-

Table 1

Origin of diet in meal	6·25 × nitrogen (per cent)	Net protein utilization (per cent)	Net dietary-protein value (per cent)	Sulphur (mgm. per cent)
Senegal	2·9	45	1·3	34
Senegal	8·4	39	3·3	82
Jamaica	5·5	66	3·6	90
Nigeria	8·0	53	4·2	109
Gambia	11·2	44	4·9	121
Nigeria	10·5	52	5·5	130
Nigeria	13·8	41	5·7	128
Nigeria	11·3	56	6·3	145
Gambia	17·8	38	6·8	172
Jamaica	12·2	60	7·3	169
Nigeria	13·5	59	8·0	194
Nigeria	16·0	52	8·3	186
Britain	14·4	61	8·8	185
Jamaica	17·8	58	10·3	197
Britain	16·6	68	11·3	197
Britain	17·9	69	12·4	203

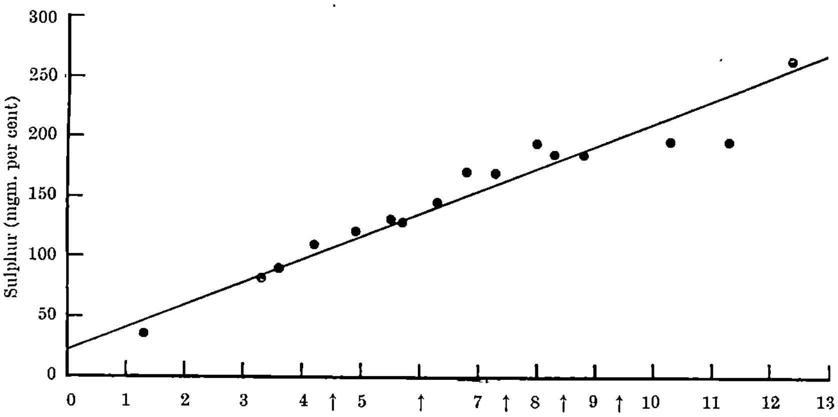

Fig. 1. Correlation between total sulphur content and net dietary-protein value (N.D.V.). Letters indicate 'safe practical allowance' for: *A*, adult; *C*, child; *T*, toddler; *B*, adolescent; *L*, lactating mother. N.D.V. = 0·0521 *S* – 1·06

chloride[11], and titration of the precipitate with standard sodium hydroxide[12].

The results are summarized in Table 1 and Fig. 1. Despite a wide variation in the percentage of crude protein and net protein utilization, a highly significant correlation between net dietary-protein value and total sulphur was found ($R = 0·967$; $P < 0·001$). In Fig. 1 this relationship is illustrated graphically, together with an indication of the 'safe practical allowance' for various age groups, calculated from the Food and Agriculture Organization report[10] by Platt and Miller[13].

In measuring total sulphur, no account is taken of the level of inorganic sulphate in the diet, the relative proportions of methionine and cysteine, or of the availability of these amino-acids. In addition, no allowance can be made with this method, or in fact with any chemical method, for the metabolic wastage of protein occurring at high levels of protein intake. It is, however, considered that none of these factors, with the possible exception of the last-mentioned, is likely to cause any serious error when dealing with complete human diets or meals.

We suggest, therefore, that the chemical method described above may provide a rapid means of assessing the nutritive value of proteins in human diets. As a further simplification, most of the chemical information may be abstracted from published data.

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STUDIES IN SYNTHESIS OF DEOXYRIBONUCLEIC ACID

Radiobiochemical Lesion in Animal Cells

A MULTIPLICITY of biochemical changes have by this time been described in animals following lethal or sub-lethal exposure to X-radiation[1]. It may now be appropriate to see if any unification of these changes is possible.

The response detectable in an intact animal is complicated by the presence of dead cells and by the adjustments occurring within the tissues following X-radiation. These adjustments may include migration of cells, proliferation of surviving cells, etc., so that the interpretation of biochemical effects later than 1–2 hr. after exposure is very difficult. We are therefore only concerned here with disturbances which can be detected immediately after irradiation and with the effects of these biochemical changes in radio-sensitive and non-sensitive cells.

Reactions associated with two sites within the cell appear to be affected shortly after exposure.

1. (*a*) Phosphorylation of nucleotides bound by the nucleus[2] is 100 per cent inhibited 3 min. after 50–100 r.[3]. Such phosphorylation has so far been demonstrated in rat lymph nodes, thymus, spleen, intestinal mucosa and bone-marrow, but not in liver, brain, kidney and pancreas. (*b*) The well-established reduction of precursor uptake into deoxyribonucleic acid is detectable in rat thymus after as little as 25 r. and is 49 per cent of the control value by 3 min. after 1,000 r.[4,5].

2. (*a*) Rat spleen deoxyribonuclease II, which is present in either the mitochondrial or the lysosomal fraction of cell homogenates, is liberated into the supernatant fraction by 30 min. after 850 r.[6]. (*b*) Mitochondrial oxidative phosphorylation is uncoupled[7,8]. With succinate as substrate the effect is detectable in rat spleen mitochondria 4 hr. after 100 r. and in rat thymus mitochondria after 50 r. After 700 r. the reduction is apparent by 2 hr.[9]. (*c*) After irradiation, phosphorylation by spleen mitochondria responds[9,10] to added cytochrome *c*.

Synthesis of deoxyribonucleic acid is a property of dividing cells, and evidence has gradually been accumulating that this does not occur continually through the life of the cell but is restricted to certain periods. The work of Howard and Pelc[11] on bean-root tips and Lajtha and his colleagues[12] with human bone-marrow cultures has indicated that synthesis of deoxyribonucleic acid occurs during a limited period in interphase—the synthetic period (S)—which is preceded by a highly radiosensitive pre-synthetic period (G_1) but which is itself less sensitive. It seems likely that in cells which are going to divide changes

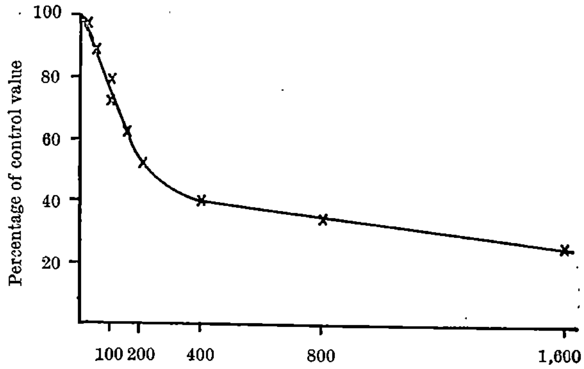

Fig. 1. The effect of total-body X-radiation on the incorporation of phosphorus-32 into rat thymus deoxyribonucleic acid 2 hr. after exposure

occur in G_1, which are an essential preliminary to the synthesis of deoxyribonucleic acid, and their inhibition by X-radiation would result in a failure of precursor uptake into deoxyribonucleic acid. The radiosensitivity of nuclear phosphorylation makes it attractive to suggest that this process may contribute to the radiosusceptibility of the pre-synthetic period. Either the phosphorylation of bound nucleotides is an essential preliminary to the synthesis of deoxyribonucleic acid, or the inhibition may be a delicate index of structural or functional changes within the nucleus not previously detected in other biochemical tests. Once the essential preliminaries have been completed, that is, the cell is entering *S*, higher exposures are required to prevent the final condensation of deoxyribonucleotides on the template.

A polyphasic response of synthesis of deoxyribonucleic acid to X-radiation is suggested from our results on the incorporation of phosphorus-32 into rat thymus deoxyribonucleic acid. The results show (Fig. 1) a very sensitive linear reduction in incorporation after 25–200 r., which is followed by a slowly increasing inhibition up to 3,200 r. It does not seem unreasonable to suggest that the initial portion of the dose–response curve corresponds to inhibition of nuclear phosphorylation and that the phase of only slowly increasing inhibition can be associated with progressive damage to the template.

A similar conclusion to this has also been reached by Lajtha, Oliver, Berry and Noyes (following communication) from autoradiographic studies of human bone-marrow cells exposed to either X-rays or α-particles in tissue culture.

These two facets of damage to the nucleus cannot be considered in isolation from the remaining part of the cell. The significance of the cytoplasm in the radiation injury has often been emphasized[13–15] and an excellent discussion of the relevant data has been provided recently by Trowell[16]. Alterations to mitochondrial reactions after exposure develop rather more slowly than those to the nucleus, but they lead to a decrease in production of adenosine triphosphate and to the liberation of enzymes, such as deoxyribonuclease II, which can exacerbate the nuclear damage. It seems probable that differences in radiosensitivity between dividing cells, lymphocytes and, for example, the liver, may be attributed to the part which the cytoplasm, and in particular the mitochrondria, can play in restoring or by-passing damage to the nucleus. In a dividing cell it is obvious that nuclear damage can prevent multiplication and, if rather large exposures are used, disturbances in the mitochondria may prevent any reversal of the nuclear disorders, although with smaller exposures mitochondrial alterations are slight.

In the non-dividing lymphocyte the volume of cytoplasm and number of mitochondria are very small[16]. Nuclear metabolism is therefore a major factor in the economy of the cell, and its inhibition may have serious consequences because of the inability of the cytoplasm to overcome the damage. In liver, on the other hand, it is likely that the relatively smaller contribution which the nucleus makes to the overall cell metabolism can perhaps be restored through the operation of the large mitochondrial reserve.

If the nucleus and mitochondria are the main regions affected within the cell, it is necessary to explain their susceptibility. Both these sites require oxygen and contain 'bound nucleotide'. Allfrey and Mirsky[17] have shown that treatment with deoxyribonuclease prevents nuclear phosphorylation, which may be restored by the addition of either deoxyribonucleic or ribonucleic acid, and Siekewitz and Watson[18] have suggested that bound nucleotide plays some part in mitochondrial oxidative phosphorylation. Ribonucleic acid–protein complexes are found in microsomes, and bound nucleotides may be part of the cell membrane ; but neither of these latter sites appears to be radiosensitive. It may be the participation of oxygen, possibly in some bound form, in nuclear and mitochondrial reactions which is the factor determining the sensitivity of these sites.

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Mechanism of Radiation Effect on the Process of Synthesis of Deoxyribonucleic Acid

SYNTHESIS of deoxyribonucleic acid occurs only for a limited period of time in interphase[1,2]. Therefore, in studying the effects of radiation on the synthesis of deoxyribonucleic acid it is important to differentiate between effects on the pre- or post-synthetic period as opposed to the synthetic period itself (process of deoxyribonucleic acid synthesis). A previous publication[3] dealt with the effects of radiations on the pre-synthetic period (G_1 period); the present report is concerned with effects on the period of synthesis of deoxyribonucleic acid (S period) itself.

Human bone-marrow cell suspensions obtained by sternal puncture were used. The methods of culturing such suspensions *in vitro*, of high-resolution autoradiography, and planchette counting have been described previously[3-5]. 300-kV. radiation was employed (HVL 2 mm. copper) with a dose-rate to the cells of 480 rads/min. Sodium formate labelled with carbon-14 (4 μc./μM) was added to the medium 1·25 μc./ml. as deoxyribonucleic acid label.

As previously mentioned[3], in human bone-marrow cells *in vitro* the duration of the period of synthesis of deoxyribonucleic acid is about 12 hr. In short-term (1½–4 hr.) incubation with formate labelled with carbon-14 more than 85 per cent of the cells which collect sufficient amount of label for a visible autoradiograph will have been in the synthetic period at 0 hr. Irradiation of such short-term cultures therefore measures the effect of radiations on the period of synthesis of deoxyribonucleic acid directly; this could be an inhibition of synthesis as well as a reduction in the rate of synthesis.

The relative biological efficiency of α-particles compared with X-radiation was measured by dissolving radon gas in the medium in which the cells were suspended. For such irradiations, small (7-ml.) culture bottles were used for cutting down the air space above the fluid. Within 30 min. 500–5,000 rads could be delivered by the α-particles to the cells; the radon gas was then removed by aeration and the cell suspensions were transferred to the regular culture bottles for incubation with formate labelled with carbon-14.

Synthesis of deoxyribonucleic acid was measured by the average grain count per labelled cell, or by the total radioactivity in 12 × 10^6 cells. Previous experiments have shown that in such short-term incubations with the doses of radiation employed, the proportion of labelled cells does not change; it is the grain count over the labelled cells, that is, the amount of deoxyribonucleic acid synthesized per cell during the time of incubation, which is depressed by radiation.

The time relationship of depression of synthesis of deoxyribonucleic acid produced by a dose of 2,000 rads X-rays is shown in Fig. 1. It indicates that: (*a*) after 2,000 rads synthesis of deoxyribonucleic acid in the cells proceeds at about half the normal rate; (*b*) extrapolation of the slope of the reduced rate of synthesis intersects the control line at about 30 min., below which time presumably no depression is measurable.

The dose–response curve for X-rays on synthesis of deoxyribonucleic acid during a 4-hr. incubation period is shown in Fig. 2. (*a*) The pooled results of fifteen experiments (●——●) suggest that the curve of depression of rate of synthesis of deoxyribonucleic acid with increasing dose can be analysed in terms of two exponential components, one with a steep slope (S_1) and the other with a shallow slope (S_2). (*b*) The dose for 63 per cent depression for the S_1 component is about 500 rads, that for the S_2 component 13,000 rads. (*c*) In any single experiment a dose of 2,000 rads may produce as little as 30 per cent or as much as 65 per cent depression (mean 50 per cent), but the slope of the S_2 component remains the same (—). (*d*) Extrapolation of the mean S_2 slope intersects the scale at 40 per cent depression, but in different experiments it intersects at between 20 per cent or 60 per cent depression. (*e*) The relative biological efficiency for radon α-particles at 500 and 5,000 rads was found to be about 0·5.

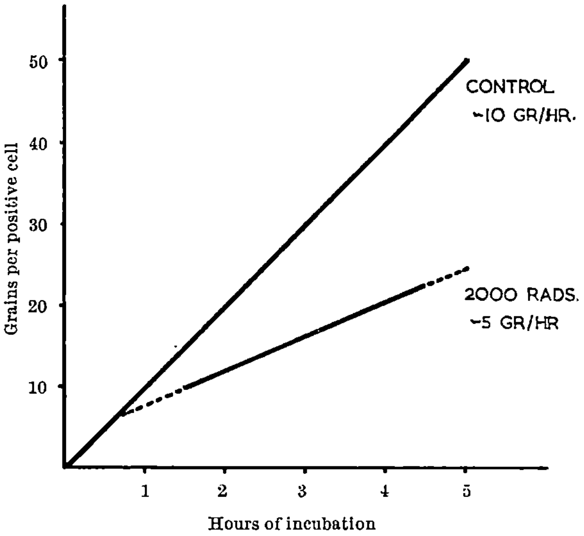

Fig. 1. Variation with time of depression of synthesis of deoxyribonucleic acid by a dose of 2,000 rads X-rays. Mean of four experiments

The experimental error of any single point on the above curves is scarcely greater than the black circles on the main curve.

It is emphasized that in these experiments practically all the cells investigated were in their period of synthesis of deoxyribonucleic acid (S period). The results, therefore, refer to effects of radiation during the period of synthesis of deoxyribonucleic acid, that is, as nearly as is possible at present, to the process of synthesis of deoxyribonucleic acid in the cell.

(1) The time relationship of depression of synthesis of deoxyribonucleic acid shows that up to 4½ hr. after a dose of 2,000 rads synthesis of deoxyribonucleic acid is not stopped, but proceeds at a reduced rate. The term 'rate' is defined here as the amount of deoxyribonucleic acid label collected per cell during unit time. It also shows that this decreased rate of synthesis does not become apparent until

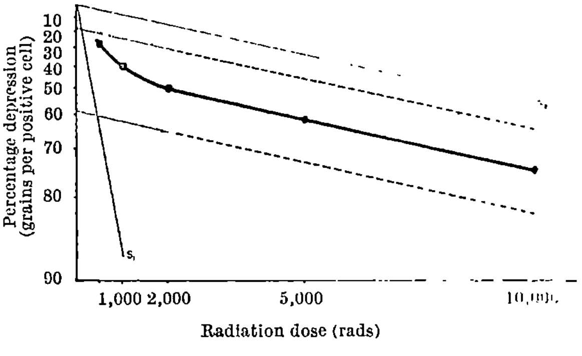

Fig. 2. Dose–response curve for X-rays on synthesis of deoxyribonucleic acid during a 4 hr. incubation period. ● -- ●, mean of fifteen experiments; ——, minimum and maximum curve (in single experiments)

some time (in our experiments probably about $\frac{3}{4}$–1 hr.) after irradiation.

(2) In view of the above, as the dose–response curve is the result of experiments with 4 hr. incubation with deoxyribonucleic acid label, it shows the depression with increasing dose of the *rate* of synthesis of deoxyribonucleic acid during a 4-hr. period.

In a 4-hr. incubation period 4-hr. 'worth' of cells would proceed from the pre-synthetic period (G_1 period) to the synthetic period (S period)—all data take this factor and the G_1 delay[3] into consideration.

(3) The dose–response curve can be analysed as two exponential components, the S_2 component giving a remarkably good straight line suggesting a single-hit type of mechanism.

The bone marrow being a heterogeneous population of cells, it was essential to determine whether the different cell types showed different sensitivities to radiation. This was not the case: pilot experiments had shown that early nucleated red cells and myelocytes show similar sensitivity in terms of radiation effect on the rate of synthesis of deoxyribonucleic acid.

Even in counting the myelocytes, one is not dealing with a pure clonal strain of cells, and therefore theoretically differences in radiosensitivity could be expected. However, in that case the dose–response curve would indicate two sharply different populations of myelocytes, one with a 37 per cent dose of 500 rads, the other of 13,000 rads. This sharp difference in the slopes of the components makes an explanation based on population differences very unlikely.

(4) A mechanism which results in decreased rate of synthesis of deoxyribonucleic acid per cell with increased dose of radiation (and not elimination of cells from synthesis of deoxyribonucleic acid) indicates that subcellular 'targets' are involved. Although the mechanism of damage is not yet clear, the exponential dose–response curve encourages one to consider a single-hit process, and to calculate the corresponding 'vulnerable volume' (a perhaps more fitting term than 'target', under our experimental conditions) from data given by Lea[6]. Thus, a relative biological efficiency of 0·5 between X-rays and radon α-rays leads to an individual volume of $4 \cdot 8 \times 10^{-8}$ μ^3 (ref. 6, Fig. 11), and a 63 per cent depression dose of 13,000 rads for X-rays would indicate 1,500 of these volumes per chromosome, a total of $7 \cdot 2 \times 10^{-5}$ μ^3 (ref. 6, Fig. 8*a*), corresponding to a total volume of $3 \cdot 3 \times 10^{-3}$ μ^3 per cell. Alternatively, these results can be considered to indicate a vulnerable volume in the form of a long filament, about 54 A. × 3·25μ per chromosome[6]. Even considering the very tentative nature of such calculations it seems clear that the dimensions are very much subcellular.

(5) The results are not sufficient to give a clear explanation as to the mechanism of the radiation effect on the process of synthesis of deoxyribonucleic acid, but based on them the following tentative hypothesis has been evolved.

The rate of synthesis of deoxyribonucleic acid in the bone-marrow cells (amount of deoxyribonucleic acid synthesized per cell per unit time) depends on two components, S_1 and S_2.

As to the nature of the S_2 component, we propose that it represents the integrity of the deoxyribonucleic acid template. Our calculations of the vulnerable volume for the S_2 component, tentative as they are, are compatible with such a concept. If, however, the nature of the radiation damage in S_2 is the breaking of the deoxyribonucleic acid double helix, then a dose of 10,000 rads should break only 0·1–0·5 per cent of the deoxyribonucleic acid molecules (mol. wt. 6×10^6 in a cell; Butler, J. A. V., personal communication). As Fig. 2 indicates a depression of at least 50 per cent due to the S_2 component alone at 10,000 rads, this may indicate that a larger functional unit is inactivated if a fraction of the deoxyribonucleic acid molecules in it is damaged—such a unit may be a part (or whole) of a chromosome. If enough parts of chromosomes (or whole chromosomes) are rendered incapable of synthesis of deoxyribonucleic acid, then the cell will synthesize: (*a*) less deoxyribonucleic acid per unit time; and (*b*) less than the full diploid amount of deoxyribonucleic acid per synthetic period.

As to the nature of the S_1 component, it may be part of the biochemical mechanism of precursor synthesis. At this stage it is not known whether the S_1 damage is destruction of an enzyme, or liberation of inhibitory substances, but it may well be a mechanism similar to that suggested by Ord and Stocken (previous communication). The delay in time of appearance of the S_1 damage may indicate destruction of an enzyme which produces some key compound. After destruction of the enzyme the cell would have to use up the compound made before destruction of the enzyme, before the lack of the compound becomes measurable. In different cells this time may be different, depending on the amount of compound available after the destruction of the enzyme. Apparently, in different cells the amount of the S_1 component may vary: a dose of 2,000 rads which destroys the S_1 component may result in only 30 per cent or as much as 60 per cent depression of the rate of synthesis of deoxyribonucleic acid. According to this concept, destruction of the S_1 component may slow down the rate of synthesis of deoxyribonucleic acid in the cell without necessarily preventing the synthesis of the full diploid amount of deoxyribonucleic acid. Experiments are in progress to elucidate the nature of these components.

(6) It has been known that in studying radiation effects on synthesis of deoxyribonucleic acid *in vivo*, changes in cell population or mitotic inhibition may obscure the picture. It was pointed out[3] that, even *in vitro*, interference with cell-cycle processes (elongation of the pre-synthetic period) have to be taken into account. It appears that even if all these are considered, the rate of synthesis of deoxyribonucleic acid in the cell depends on more than one factor. Until all these are elucidated one cannot interpret radiation effects in biochemical terms.

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LETTERS TO THE EDITORS

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Electric Field Theory of Auroræ

From time to time theories of the aurora have been proposed which invoke locally developed electric fields as the mechanism causing acceleration of solar particles into the relatively low levels of the ionosphere at which visible aurora usually occurs. However, these theories have been concerned mainly with an explanation of the classical idealized magnetic storm, treating the auroral phenomena as a by-product, and not attempting any detailed explanation of auroral morphology. One notable exception is the recent work of Chamberlain[1], in which an attempt has been made to explain the luminosity-height characteristics of an auroral ray in terms of an electric field in the ionosphere. The purpose of this communication is to present a crude qualitative description of the development of a typical auroral display as a result of the growth of an electric field in the ionosphere.

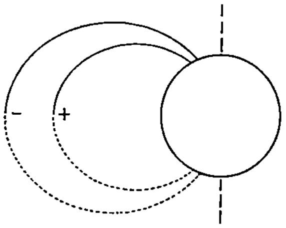

Fig. 1

Fig. 1 shows two lines of the geomagnetic field intersecting the Earth's surface in auroral-zone latitudes. Let us suppose that a potential difference is applied between these lines at their outermost extension as shown, without for the moment considering how this voltage is set up. The electrical conductivity of an ionized gas with an applied magnetic field is not isotropic[2], the conductivity transverse to the field lines being less than that along the field lines by a factor:

$$\frac{\nu^2}{(\omega_H^2 + \nu^2)}$$

where ν is the collisional frequency and ω_H is the radian gyrofrequency in the magnetic field. The values of ν and ω_H will be dependent on the type and charge of the particles under consideration, but we will restrict ourselves meanwhile to considering the electrons in the gas. At distances of the order of the outermost extent of the field lines, the collisional frequency is extremely small, so that the current flow will be strictly along the field lines, and the conductivity will be very large due to the long mean free path. As we penetrate the ionosphere, the conductivity transverse to the field lines will gradually increase since ν increases more rapidly than ω_H. The actual value of this transverse conductivity at any height will, however, also depend on the electron density at that height, and will vanish completely below the E-region, where the night-time electron density becomes zero.

The picture, then, is of a current flow along the field lines and across the ionosphere in a meridional direction over a finite range of heights. This idea of a discharge via the ionosphere is by no means new—the same mechanism was invoked by Martyn[3]; but no detailed consideration of its effects on auroral morphology was given.

It is reasonable to assume that the electric field at any point around this circuit will be dependent on the local conductivity, by analogy with Ohm's law. The situation is complicated by the fact that the effective conductivity at any point is itself dependent on the field, as has been pointed out by Chamberlain[1]. However, we can still say that the total potential drop will distribute itself around the circuit in such a way that the regions of low conductivity will experience a relatively high electric field.

This field will reach its highest value at the lowest point at which ionization exists, that is, at the bottom edge of the E-region in contact with either line of force. It is thought that the meridional field will be less than this because here the flow of current takes place over a very large area. If the total potential drop is now allowed to increase steadily, we shall start to see visible light first at E-region heights, corresponding to excitation of the air molecules. The appearance would be that of a homogeneous arc lying along a parallel of geomagnetic latitude. The important factor here is not the field alone, but the product of field and mean free path ($E\lambda$). By considering the energy distribution of electrons in an electric field, Chamberlain[1] has derived the expression:

$$J = kN(E\lambda e)^{2/3} \qquad (1)$$

for the current density, J. Here k is a constant, N is the electron density and e is the electronic charge. From this we obtain:

$$E\lambda = \frac{1}{e}\left(\frac{J}{kN}\right)^{3/2} \qquad (2)$$

Equation (2) shows us that as we travel up from the E-region into regions of increasing electron density, $E\lambda$ decreases, so that a relatively large drop in potential would be necessary to produce excitation. However, it is conceivable that at very great heights, N again becomes so small that $E\lambda$ can reach excitation proportions. Since the atmosphere probably contains a large proportion of hydrogen at these heights, we might see a glow of hydrogen emission which would appear to the south of the arc, due to the bending over of the field lines as shown in Fig. 1. This reasoning, of course, assumes that J is constant along the field line, which may be true to a sufficient degree of accuracy for our purposes.

If the potential continues to increase, the arc will start to extend vertically, until eventually the field in the meridional direction reaches a large enough magnitude to produce ionization along the horizontal portion of the path through the ionosphere. Once this happens, the total resistance of the 'circuit' decreases suddenly, leading to a large increase in density of current, coinciding with the appearance of light across large areas of the sky. At the same time, the conductivity of the horizontal portion of the circuit becomes greater in comparison with that of the vertical portion, so that more of the total potential drop appears across the vertical portion, causing the electrons to be accelerated more rapidly.

It is suggested that a process of this type might account for the auroral break-up phenomenon, and that the vertically accelerated electrons are the cause of the X-rays which have been reported as appearing when quiet arcs break up into active forms[4]. The display will continue until the voltage has been discharged.

It is interesting to note that during daytime, N is so much larger that this discharge would occur much more rapidly without the production of extra ionization, so that aurora would be expected to be a night-time phenomenon. The same reasoning might explain the summer minimum in auroral activity. To explain the equinoctial maximum, we must remember that there are, in fact, two 'circuits' in parallel, one in each hemisphere. During the northern winter, most of the discharge will occur through the more highly conducting southern ionosphere, and only near the equinoxes will the two conductivities become nearly equal. Another interesting consequence of this mechanism is that the detailed form which an auroral display takes might be expected to be dependent on the local ionospheric conditions existing before the display begins. This point could be fairly easily checked.

It must be said that the foregoing remarks in no way pretend to form a theory of aurora. They have been presented merely to direct attention to what may prove to be a useful line of thought. Many questions of auroral behaviour have been left unanswered, and it is hoped that a quantitative examination of the validity of the process, which is now under way, might provide some of the answers.

I am indebted to my colleagues at the Geophysical Institute, and especially to Dr. C. T. Elvey, for stimulating discussion of this material.

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Health Hazards from Powerful Radio Transmissions

For many years radio-frequency heating has been used under controlled conditions for medical purposes. It is clear that radiation from a powerful transmitter might also cause heating of body tissues, and this, if excessive, would be harmful. While precautions have always been necessary to prevent this, the problem has recently become more important, since the powers and aerials now used are such that levels of field-strength considered to be dangerous can occur at some distance from the transmitter. In fact, this may be an important consideration in siting powerful transmitters.

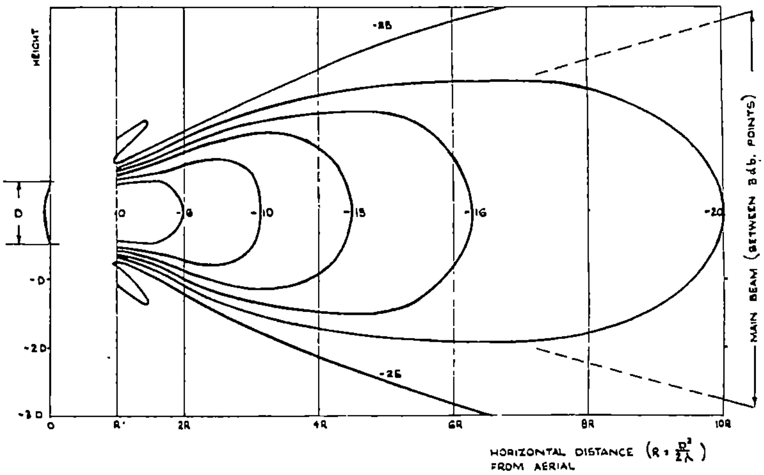

Fig. 1. Field-strength contours (in decibels) due to paraboloid of diameter D in free space

The level of field-strength which is dangerous was discussed by Schwan and Li[1]. They state that the maximum steady flux tolerated by the body is 30 mW./cm.^{2} for frequencies less than 500 Mc./s., 10 mW./cm.^{2} for frequencies between 1,000 Mc./s. and 3,000 Mc./s., and 20 mW./cm.^{2} for higher frequencies; for short exposures a much greater flux can be tolerated, for example, 300 mW./cm.^{2} for 1 min. It is of interest to predict, for particular powers and aerials, the positions at which the field will exceed the critical value.

Consider a simple aerial, a paraboloid fed by a horn; and assume that the gain of the horn is 8 db. (relative to an isotropic radiator), and the field at the edge of the reflector is 10 db. less than the field at the centre. The field outside the reflector will be less than this. It follows that, except in the region between the horn and the reflector, the direct field from the horn can be taken to be less than it would be if the horn were an isotropic radiator. This enables us to specify a 'danger distance' from the horn, for example, 3 m. for a horn radiating 10 kW. It is clear, therefore, that the danger area due to direct radiation from the feed is small.

This does not apply to the danger area due to the main field of the aerial. Fig. 1 shows the rough shape of the main field at distances between R and 10 R from the aerial, where R is the 'Rayleigh distance', $D^2/2\lambda$, D being the diameter of the aerial. The contours are drawn relative to the 'maximum power flux'. This is taken to be the power flux on the axis at the Rayleigh distance. It is approximately equal to $2{\cdot}3P/D^2$, where P is the power. The power flux will in fact exceed this by up to $3\frac{1}{2}$ db. at some positions within the Rayleigh distance[2].

If P is 20 kW., D is 10 m., and λ is 35 cm. (reasonable parameters for a tropospheric scatter system), then the maximum power flux is 46 mW./cm.^{2}, and R is 141 m. If we add a factor of safety of 4 to Schwan and Li's figure of 10 mW./cm.^{2}, then the safe contour is 13 db. less. If the mean height of the aerial is 10 m. above the ground and the ground is level, then the whole of the ground between 270 m. and 620 m. (say half a mile) in front of the aerial is within the danger zone, since the flux exceeds the safe flux at heights below 2 m. This would normally by unsatisfactory. It can be remedied either by increasing the mean height of the aerial to 14 m.

or by tilting the aerial upwards by 0·45°, that is, about one-fifth of a beam-width. Such an aerial could therefore safely be placed on a cliff overlooking the sea, or with ground sloping away in front of it at an angle exceeding 0·45°.

The field at distances from the aerial less than the Rayleigh distance is largely confined within a cylinder the base of which is the reflector. The field below this cylinder is generally about the same as it is at the same height at the Rayleigh distance[2]. For example, for the aerial considered above (10-m. reflector, mean height 10 m., wave-length 35 cm.) the field at a height of 2 m. above the ground varies as one moves away from the aerial but is always more than 20 db. less than the 'maximum power flux' up to a distance of 200 m.; as one moves farther away, it increases to about 10 db. at 340 m., and then decreases continuously, reaching 14 db. at 680 m. and 20 db. at 1,380 m.

It is worth pointing out that the fields computed are those in free space. The ground will reflect radiation, the reflexion coefficient being dependent on wave-length, polarization, and the dielectric constant and roughness of the ground[3]. If the reflexion coefficient is -1 (horizontal polarization, smooth earth), then the field-strength at some points will be 6 db. greater than that in free space. This would account completely for the 'factor of safety' of 4 taken into account above.

An ionospheric scatter system on, say, 40 Mc./s., would not in general have such a large danger area, since the maximum power flux would be smaller and the allowable power flux would be greater. Radar systems will also have a smaller maximum power flux, and so are unlikely to be dangerous except near the axis of the beam. Even right in the beam, there will be no danger provided that the aerial is kept scanning. It might be worth while to point out that medium powers and small aerials can be dangerous; for example, 100 watts and 1 metre diameter gives a maximum flux of 23 mW./cm.^{2}, well above the tolerable limit; the Rayleigh distance is, however, quite small, being only 5 m. for a wave-length of 10 cm.

All these conclusions are subject to review in the light of new biological findings. The work of Schwan and Li[1] seems rather conjectural, but is the only solid basis available at present, apart from serious effects caused by much higher power densities[4]. It is clear that the adequate application of safety precautions would be much facilitated by a simple instrument which indicates whether or not a field of, say, 2 mW./cm.^{2} is being exceeded. It is also of importance for pulse radar to know whether a strong field, say, 3 kV./m., lasting for a microsecond or so, can do any harm to the body apart from its heating effect.

I am indebted to the Engineer-in-Chief, Marconi's Wireless Telegraph Co., Ltd., for permission to publish this communication.

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Bismuth–Tellurium Photo-voltaic *p–n* 'Sandwich' Layer

IT has been fairly well established[1,2] that bismuth telluride changes conductivity type[1,2] with the excess of tellurium over stoichiometric proportion between 1 and 2 atomic per cent[3]. It has been assumed that each excess Bi(Te) atom replacing the Te(Bi) atom in the single crystal of Bi_2Te_3 behaves as an ionized acceptor (donor)[1-3].

It seemed to me that if the conductivity type of a layer of semiconductor, approximately 1μ thick, evaporated on to the surface of a plate of insulating material would change from *p* (or *n*) to *n* (or *p*) in the direction perpendicular to the plate surface, it would possess the photo-voltaic property. An attempt to process such a layer was successful. I then reasoned in the reverse direction. Both the fact that the layer has shown the photo-voltaic property and the method of its preparation have suggested that the layer is of a 'sandwich', *p–n* barrier type.

A layer of bismuth was evaporated *in vacuo* on to the surface of a glass plate 8 cm. × 2 cm., covering little more than half of its length. Then a layer of tellurium was evaporated on to the uncovered portion of the plate overlapping the end section of the bismuth film in the middle area of the plate. Thus, the central portion was a 'sandwich' type Bi–Te layer of the area of $\frac{1}{4}$ cm. × 2 cm., while the remaining bismuth and tellurium portions served as leads which enabled the connexion of the 'sandwich' layer in series with a galvanometer and eventually with a battery.

The layer was then heated *in vacuo* up to a temperature of about 150–200° C. for a few minutes. After removing it from the evaporator, the layer showed the following properties in atmospheric air. Its dark resistance was about 7,000 ohms at room temperature. Under an intensity of illumination of 25×10^{-5} lumens/mm.^{2} given by a tungsten lamp it decreased by about 15–20 per cent. The photo e.m.f. generated by the same radiation intensity amounted to about 50 millivolts. The bismuth electrode acquired positive potential on illumination in respect to the tellurium electrode. The response time was of the order of a few msec., proving the effect to be photo-electric.

Tentatively, these effects could be accounted for in the following way. As soon as crystallites of bismuth in the 'sandwich' portion of the layer come in contact with those of tellurium, diffusion of the tellurium (bismuth) atoms, enhanced by elevated temperature, into the bismuth (tellurium) crystallites occurs. It is presumed that one, or both, of two things may then happen: either tellurium (bismuth) crystallites with bismuth (tellurium) wrong site atoms, acting as acceptors (donors), or bismuth (tellurium) rich bismuth telluride (Bi_2Te_3) crystallites are formed, in the latter case with (0001) planes parallel to the glass plate surface.

In both cases *p–n* barriers would be formed, with the *p*-type material on the side of the bismuth electrode, and the *n*-type material on the side of the tellurium electrode. Electron (hole) type conductivity in the planes parallel to the surface of the plate glass may also occur in the bismuth (tellurium) portion of the sandwich layer. Photo-conductive layers of Bi_2Te_3 have been made by other investigators[4-5], but no details have been revealed.

The above method could perhaps be applied to other compounds characterized by low temperature of dissociation and considerable difference in the boiling temperatures of the elements (constituting elements belonging to groups occurring near each other in the periodic table of elements—narrow forbidden bands). To such compounds the 'evaporation method' applicable to compounds such as PbSe, PbTe, CdS[6,7] which do not dissociate during the evaporation (constituting elements belonging to groups occurring far from each other—wide forbidden bands) cannot be applied.

The method described seems to be promising in processing layers consisting of elements which obey the (8–*N*) rule in forming single crystals, and the behaviour of which can be explained in terms of Brillouin zones.

I am indebted to Prof. D. C. White, Prof. J. F. Reintjes and Dr. J. W. McArthur of the Servomechanism Laboratory of the Massachusetts Institute of Technology for making available to me the facilities of the Laboratory.

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Evidence of Lattice Defects preceding Oriented Transformations during the Heat Treatment of Kaolinite

RECENTLY, Brindley and Nakahira[1] have expressed their belief in the existence of a defect silicon-spinel phase preceding the transformation into mullite of kaolinite. This view has also been endorsed by Steadman and Youell[2]. Brindley and Nakahira[1] have obtained evidence that the spinel phase has a high degree of orientation with respect to the original kaolinite crystal. Oriented transformations of this type have been observed by Bernal *et al.*[3] and by Steadman and Youell[2]. It may be mentioned here that I also observed oriented transformation of kaolinite into mullite during its heat treatment, the (002) plane of kaolinite being converted into the (231) plane of mullite[4]. The aim of this communication is to present experimental evidence for the existence of disordered phases preceding the formation of mullite during the heat treatment of kaolinite.

A sample of kaolinite from Singhbhum, India, was tested by the differential thermal analysis method. This resulted in two prominent endothermal peaks at 140° C. and 550° C. each and a prominent exothermal peak at 1,000° C. This is in conformity with the observations of Spiel, Berkelheimer, Pask and Davies[5]; Ross and Kerr[6]; and Grim and Bradley[7]; and showed that dehydration started at 140° C., was almost completed at 550° C. and a new phase, the mullite, appeared at 1,000° C. X-ray diffraction powder photographs of kaolinite were taken after its heat treatment to 510° C., 692° C. and 930° C., that is just before and after dehydration of kaolinite was mostly complete and during the formation of Brindley's spinel phase. The line profiles of the various reflexions were studied with the help of a Hilger non-recording microphotometer. From the observed line profiles the effects of particle-size broadening were eliminated, and the pure diffraction line profiles were recovered by applying the method due to Stokes. It is observed that pure diffraction line profiles of reflexions corresponding to the (002), (113), (131), (060), (331), (106) and (033) planes of kaolinite are asymmetrical and that the asymmetry of the curves increase with temperature. This means, according to Hendricks and Teller[8] and Wilson[9], that there are defects in the interlayer distances in those directions and that the disorder increases with temperature. Now these are the planes which ultimately[4] become converted into the (231), (422), (822), (0,12,0) and (444) planes of mullite. (Indexing of the mullite planes has been carried out according to the lattice parameters proposed by Gillery[10].) Thus it becomes apparent that the oriented transformation of kaolinite into mullite is preceded by lattice disorders which increase with temperature until the formation of the new phase starts.

A detailed account of the work will be published shortly.

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A Method of studying the Variation with Temperature of Ultrasonic Absorption in Liquids

THE study of the temperature coefficient of ultrasonic absorption in liquids is of fundamental importance for an understanding of the particular molecular mechanism responsible for the phenomena observed. The dependence of absorption in liquids on temperature has been studied by a number of workers by taking measurements of absorption at different temperatures by the pulse method[1] and by the interferometer method[2].

The present communication describes a simple method of measuring the temperature coefficient of absorption using a fixed-path double crystal interferometer with the liquid under study enclosed between identical sender and receiving crystals. The sender crystal is excited at its fundamental by the radio-frequency voltage output from a crystal oscillator and power amplifier, and the voltage across the receiving crystal is measured by a sensitive valve voltmeter. As the liquid in the ultrasonic cell is heated gradually the deflexion in the valve voltme is found to change continuously, giving sharp max at those temperatures at which a stationary wa

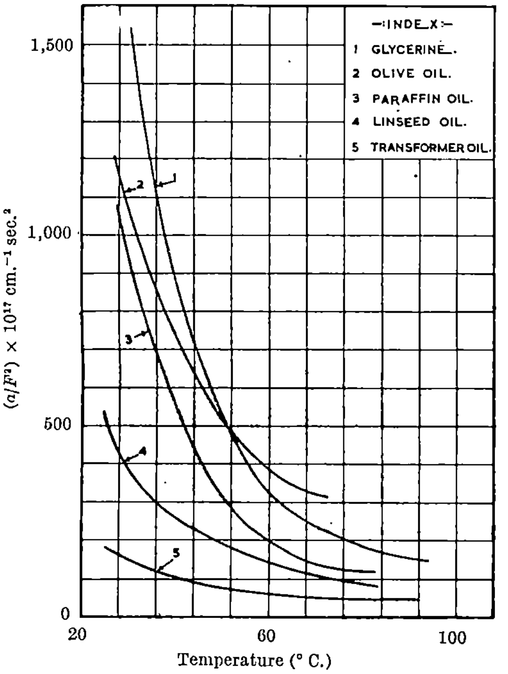

Fig. 1

formed in the liquid column. Following the treatment of Musa[3], it can easily be shown that these maxima occur at those temperatures satisfying the relation :

$$L = (2n + 1)\lambda/4 \qquad (1)$$

where L is the length of the liquid column and λ is the wave-length of the ultrasonic wave. The expression for the voltage V across the receiving crystal can be written in the form :

$$V_m = K/\sinh(\alpha L + \beta) \qquad (2)$$

where α is absorption per unit length and K is a constant. For highly viscous liquids, the value of the parameter β can be safely assumed to be small compared with αL, so that it can be neglected. Equation (2) can easily be utilized for the calculation of α at various temperatures provided K is evaluated by assuming a known value of α at one temperature determined by a standard method. By measuring the voltages across the receiving crystal at various temperatures at which maxima are observed and using equation (2) the absorption coefficient α is calculated at several temperatures and a graph can be drawn showing the variation of α with temperature. The method has been applied to some common viscous liquids and the results are shown in Fig. 1. The results for olive oil, glycerine and linseed oil are in good agreement with those of Verma[4] and Hunter[5]. It will be noticed that in almost all these oils the absorption coefficient falls off rapidly in a more or less exponential manner with increase of temperature.

The method has the advantage that there are no movable parts, and the equipment is quite simple. The accuracy of the determination of the variation of α, which is entirely dependent on the indicating voltmeter and the device measuring temperature, is found to be better than 5 per cent. The absolute accuracy of α depends on the accuracy of the value of α assumed or measured at one temperature. The method has the advantage that, with the same apparatus, the temperature coefficients of both ultrasonic velocity and absorption can be determined simultaneously using the same set of readings. It has been possible at present to apply this method only for the study of temperature effect on absorption in highly absorbing liquids having large temperature coefficients. However, the method can readily be modified for application to other liquids.

We wish to thank the Council of Scientific and Industrial Research for financial assistance for this project.

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Diffraction of Light by Ultrasonic Waves, Oblique Incidence and Sound Intensity

THE experimental results reported in a previous communication[1] confirm the existence of several maxima for the second- and the third-order diffraction lines at oblique incidence and at low sound intensities, when the sound wave-length is small as expected by the closed intensity expressions of Aggarwal[2]. We have now observed for this small sound wave-length that, when the sound intensity is slowly increased, the number of these maxima diminishes. Further, the emphasis appears to shift towards the first Bragg angle, instead of the diffraction order attaining the maximum intensity at its respective Bragg reflexion angle. The secondary maxima for the second- and third-order diffraction lines at the Bragg angles corresponding to the higher orders slowly disappear, until the maximum intensity occurs only at the Bragg angle corresponding to the first order.

The experimental procedure was the same as that described earlier. Fig. 1 gives the results for the second order of the diffraction pattern on one side in terms of the Bragg angle at three different sound intensities. Here $\alpha/2$ is the reflexion maximum for the first order.

The graph shows that the second order attains three peaks at $\alpha/2$, α and $3\alpha/2$ at the lowest sound intensity (radio-frequency volts on the crystal: 22) which diminish to two at $\alpha/2$ and α with the increase in the sound intensity (radio-frequency volts : 54)

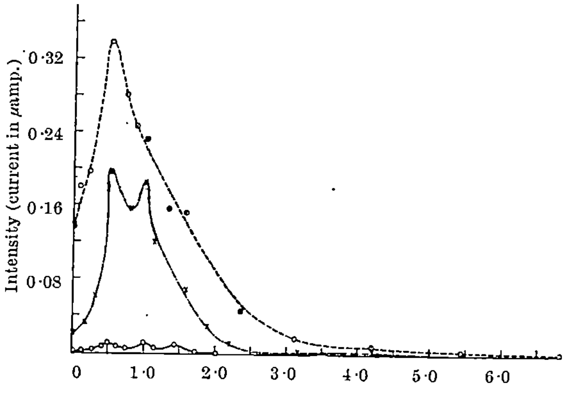

Fig. 1. Radio-frequency voltage : ○, 22 V. ; ×, 54 V. ; ○, 86 V.

and to only one at $\alpha/2$ with the further increase in the sound intensity (radio-frequency volts: 86). The pattern for the third order, which is not reproduced here, follows a similar trend; while that for the first order attained only one maximum at $\alpha/2$ irrespective of the sound intensity.

This phenomenon observed by us cannot be explained completely by any of the existing theories[3]. Aggarwal's closed intensity expressions become less accurate at higher sound intensities. However, from the series solution extended by Aggarwal[2], one sees that the variation in the intensity of a particular order is more pronounced for lower sound intensity. Thus the peaks decrease in number with the increase in the sound intensity. The results can only be qualitatively visualized on the basis of multiple diffraction. When the diffraction pattern contains many orders, the intensity of the lower order lines is the resultant of the contribution and redistribution from and to the lower as well as higher orders, while the contribution to the intensity of the highest order comes only from the lower orders. Therefore the variation in the intensity of a particular order will be more pronounced only when that particular order is the highest order in the pattern, or in other words, when the sound intensity is low.

The results can be explained mathematically only if one is able to obtain closed intensity expressions by considering the situation that all the orders exist simultaneously. Because of the mathematical difficulties in obtaining such a solution, a physical conception only is suggested at this stage.

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Continuous-Flow Method for the Study of Microbiological Processes in Soil Samples

The existing means of studying microbiological processes in soil samples are derived from the classical methods of microbiological cultivation. They are based on the principle of a single enrichment of the soil with the appropriate substrate. The processes occurring there can be expressed by a curve characteristic of microbiological processes in closed systems. Even if these methods have produced some valuable results they have certain disadvantages, for example, the usually high initial substrate concentration and the fact that the exhaustion of the substrate causes the termination of the cycle. The first disadvantage of these classical methods of soil microbiology can be removed by the percolation technique[1,2], which makes it possible to supply the soil sample at a considerably lower concentration than required for batch cultures. But even in this case the substrate concentration undergoes changes in the course of the experiment and is exhausted in the end.

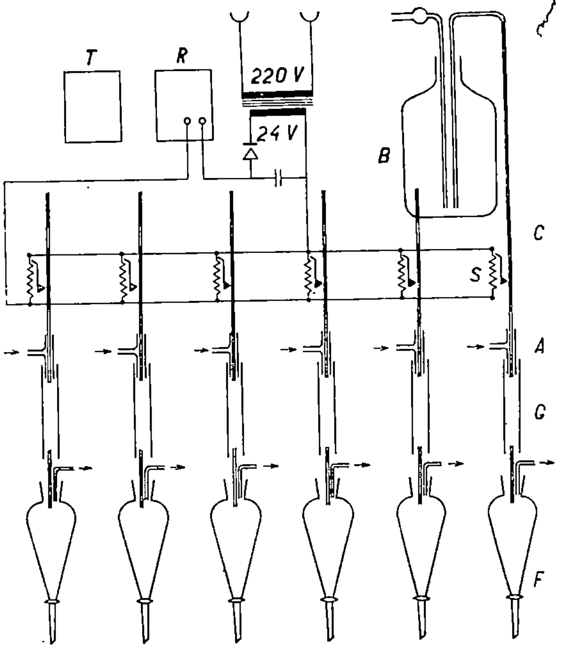

Fig. 1. A schematic representation of the apparatus for the continuous-flow method for the study of microbiological processes in soil samples

We have devised a method which makes it possible to introduce into the soil continually any desired amount of substrate the transformation of which is studied. Unlike in the percolation technique the solution passes through the soil not to return any more into circulation. It is basically an application of the continuous-flow method of culture of micro-organisms to the study of microbiological processes in the soil[3–6].

We have used an apparatus (Fig. 1) consisting of six cultivation units and a feeding mechanism. The stock solution inflow is regulated by electromagnetic screws[7] *S*, closing the rubber tubing through which the liquid passes from the stock bottle *B* to the growth tube *G*. The screws are controlled by a time switch *T* and by a slow-down relay *R*, which makes it possible to change the period of opened tubing between 0·5 and 2 sec.; the intervals between the individual impulses causing the screw to be released can vary between 15 sec. and 5 min. This mechanism ensures a constant flow and permits regulation of its rate. Capillary tubing *C* included in the circuit increases the regularity of amount of liquid passed in.

The cultivation unit is fundamentally identical with the percolation apparatus described by Audus[8] adapted for continuous flow. The soil sample is placed in a glass tube *G* closed at both ends with rubber stoppers. At the upper end of the cultivation tube the rubber stopper holds a wider glass tube with a side-arm *A* for passing in air and with a thin glass or capillary tube for passing in the nutrient medium which is connected with the stock bottle. After passing through the soil, the solution is collected in a separation funnel *F*. The stopper closing the separation funnel is provided with three holes, for the connecting tube from the cultivation flask, for an outlet to the pump and for a tube with a stopcock filled with an absorbent for the absorption of carbon dioxide; it serves also for passing air into the separation funnel when the collected solution is being removed.

The passage of the solution and the aeration of the soil are ensured by a constant suction similar to that in Audus's apparatus[8]. The introduced air is purified by removing carbon dioxide, and after passing through the soil it is introduced into the absorption flask with alkali; there the amount of carbon dioxide produced is estimated. The rate of air passing through is regulated by needle valves.

We have used this apparatus for studying nitrification and transformation of glucose in soil samples. When a glucose solution is passed through, the decrease in glucose concentration can be estimated as well as the production of carbon dioxide and the formation of volatile acids. We found that the formation of carbon dioxide and the volatile acids (related to the amount of glucose utilized) by the soil microflora is lower in the presence of nitrate than when a glucose solution containing no source of nitrogen is used. Only acetic acid could be detected by means of paper chromatography. The results show that under certain conditions an equilibrium state is established in the soil.

The method has principles in common with the method of heterogeneous continuous-flow cultivation of micro-organisms using a solid carrier. Similarly, as with continuous cultivations, it is possible also in our case to supply the soil continually with substrate at a considerably lower concentration than with other current methods. However, it is possible to prevent the exhaustion of the substrate and to ensure a sufficient amount of nutrients in the soil. Thus the soil population can be maintained at a certain level determined by the rate of flow and by the concentration of essential nutrients. As the controlling growth factor, an energy source, a nitrogen source and the like can function. It is also possible to follow the transformation of various substrates one after the other and to influence the composition of the soil microbial association.

Detailed results are to be published elsewhere.

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Thermal Annealing of Chemical Radiation Damage

AT present the only observations on the thermal annealing of chemical radiation damage appear to be some measurements on potassium nitrate reported in 1955[1]. These measurements did not include isothermal kinetic studies, nor do they appear to exclude some possible alternative explanations of the observations. We have made measurements on the isothermal annealing of radiolysed lead nitrate and subsidiary experiments which seem to exclude any alternative explanation of the results. The experiments were conducted on a sample of vacuum-dried lead nitrate crystals sieved to between 80 and 100 mesh. The crystals were irradiated to a dose of about 50 Mr. with 2 MeV. electrons from a Van de Graaff accelerator. A typical plot of the disappearance of the nitrite, produced by the irradiation, upon thermal annealing of the crystals is shown in Fig. 1.

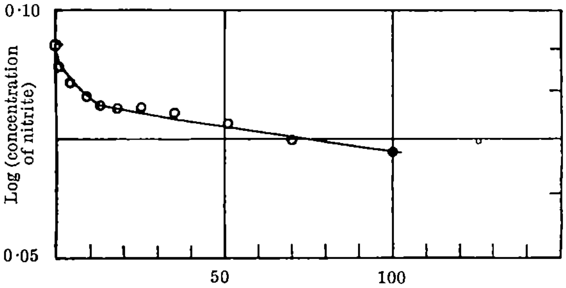

Fig. 1. Thermal annealing of irradiated lead nitrate

The possibility that the observed effect arose from aerial oxidation was excluded by showing that virtually the same annealing occurred whether the crystals were heated in air or *in vacuo*. Another possibility that the disappearance of the nitrite was due to thermal decomposition of the lead nitrite, to give lead oxide and oxides of nitrogen, was excluded by showing that in synthetic mixed crystals of lead nitrate and nitrite, prepared by crystallization from a solution of the nitrate and nitrite, the concentration of nitrite was unchanged after heating for 65 hr. at 150° C. *in vacuo*. It is concluded that the effects observed represent a true annealing of the chemical radiation damage. Similar experiments have shown that photolysed lead nitrate crystals can be annealed in the same way.

Such an effect is implied by the model for the radiolysis recently proposed by Cunningham and Heal[2], but the kinetic pattern of the recombination is more complex than the unimolecular recombination indicated by this model. A detailed account of the results and an analysis of the kinetic aspects will appear shortly.

We are indebted to Tube Investments Research Laboratory, Hinxton Hall, Cambridge, for carrying out the irradiations.

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Polymorphic Transitions in Anhydrous Sodium Sulphate

Kreidl and Simon have noted[1] that form V, the stable low-temperature form of sodium sulphate, was transformed, when in contact with water, directly and reversibly to the hexagonal high-temperature form I. This occurred at a temperature of about 238° C.

We have observed an irreversible change from form V to form I in the dry state at a temperature of only 176° C. (approximately). The observation was made in a high-temperature X-ray diffraction camera with the sample loosely packed in an open-ended quartz tube. Fig. 1 shows diffraction patterns recorded at temperatures of 161°, 176°, 180° C., and room temperature, in that order. These show respectively form V, a mixture of forms V and I, form I and form III.

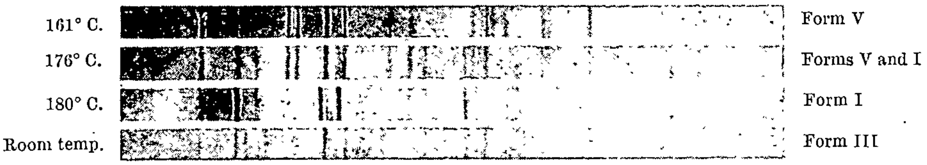

Fig. 1. X-ray diffraction patterns of anhydrous sodium sulphate. Sequence obtained during heating and cooling

From time to time in these laboratories we also have observed sodium sulphate to be present as form V after strong heating. In these cases, unlike Kreidl and Simon's experiment, cooling was not rapid nor was water likely to be present. We have not yet investigated the factors responsible for this change, which is contrary to the hitherto accepted behaviour of sodium sulphate.

I wish to thank the Directors of "Shell" Research, Ltd., for permission to publish this communication.

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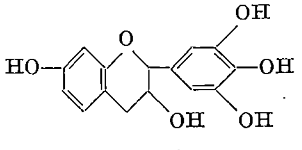
Black Wattle Catechin

Condensed tannins present in black wattle or commercial 'mimosa' extracts from the bark of *Acacia mollissima* show absorption behaviour ($\lambda_{\text{max.}} = 203$ and 280 mμ) in the ultra-violet spectrum[1], which is typical of the natural catechins and flavan-3.4-diols[2] and also of their constituent phenols. Furthermore, the degradation products resulting from the fusion of the tannins with alkali under anhydrous conditions (mainly resorcinol and gallic acid, but also phloroglucinol and protocatechuic acid), and from alkaline permanganate oxidation of the methylated tannins, resemble those degradation products usually obtained by similar methods from flavans[3]. On such evidence and by analogy with Freudenberg and Maitland's[4] earlier concept of 'quebracho catechin', one of us previously[5] regarded the catechin structure, 3.7.3′.4′.5′-pentahydroxyflavan (I), as a possible prototype of many of the complex tannins present in black wattle extract.



(I)

Recently, by means of methods outlined by one of us[6], constituents *G*, *H* and A_2 of wattle tannins[6] have been isolated in pure crystalline form and shown to be catechins. These rank among some of the major catechin components of the extract.

Constituent *H*, $C_{14}H_{15}O_6$, melting point 205–7° C., $[\alpha]_D^{20} = -10 \cdot 7°$, $\lambda_{\text{max.}} = 203$ and 281 mμ, gives colour reactions and degradation products indicative of the presence of resorcinol and pyrogallol nuclei only. Assuming the substance to be a flavan, the probable presence of five hydroxyl groups could be deduced from its chromatographic behaviour. Methylation with diazomethane afforded an O-tetramethyl derivative, melting point 140–1° C., $[\alpha]_D^{20} = -21 \cdot 6°$, showing that four hydroxyl groups are phenolic. The remaining aliphatic hydroxyl could be acetylated affording a mono-acetyl tetramethoxyl derivative, melting point 73° C.

These constants are in excellent agreement with those obtained by Weinges[7] for (−)-robinetinidol of structure I (and its corresponding derivatives), which was isolated from the hydrogenation of (+)-7.3′.4′.5′-tetrahydroxyflavan-3.4-diol (*leuco*-robinetinidin). This (−)-robinetinidol and constituent *H* from black wattle tannins show identical infra-red absorption curves over the range 2·5–15μ, and migrate to identical positions on paper chromatograms in three different and selective solvent systems. Mixed melting points of the corresponding derivatives show no depression. The presence of an *epi*-modification (2.3-*cis* substituents) of robinetinidol in wattle extract is also suspected from chromatographic evidence.

This, therefore, represents the first recorded isolation of a catechin (flavan-3-ol) of the resorcinol series from natural sources. The isolation of (−)-robinetinidol (2.3-*trans* substituents) also suggests that (+)-robinetinidol might occur naturally, as recently found for the enantiomorphous pair (+)- and (−)-7.3′.4′-trihydroxyflavan-*cis*-3.4-diol[8], and in apparent contrast with the phloroglucinol series of catechins, for example, gallocatechin, catechin and afzelichin, where mainly (−)-*epi*- and (+)-forms occur in plants.

Constituents *G* and A_2 of wattle extract were previously identified as (+)-catechin and (+)-gallocatechin respectively by means of paper chromatography by one of us[9]. This tentative identification is confirmed by their isolation and comparison with the same compounds obtained from *Casuarina equisetifolia*[10].

Our sincere thanks are due to Dr. K. Weinges, and to Prof. Karl Freudenberg, of the Chemical Institute, University of Heidelberg, for advance information regarding (−)-robinetinidol and also for specimens of the synthetic compound and its derivatives; also to Dr. J. R. Nunn, of the National Chemical Research Laboratories, Council for Scientific and Industrial Research, Pretoria, for kindly performing the infra-red comparisons.

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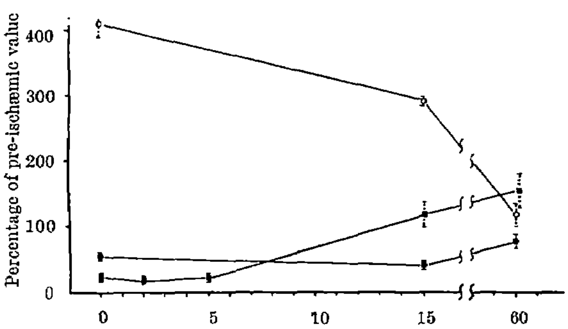
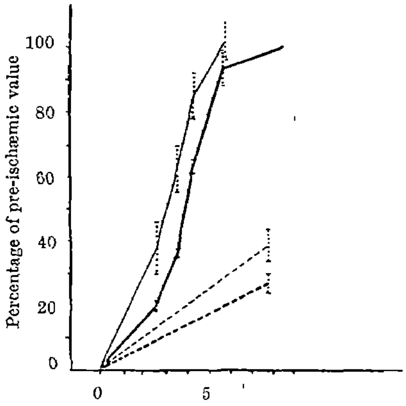
Evidence for a Relation between Creatine Phosphate Level and Polarity of the Cerebral Cortex

THE surface of the cerebral cortex in rats is 15–20 mV. positive against other electrically indifferent sites[1,2]. This steady potential can serve as an indicator of brain survival[3,4].

In the present study we attempted to characterize metabolic processes that might participate in maintaining normal cortical polarity. For this purpose the levels of some metabolites were determined in the rat brain during the various phases of steady potential changes caused by transitory brain ischæmia and following resuscitation. Rats anæsthetized with 'Dial' were used throughout. The polarity of the cerebral cortex was measured between an area damaged by thermocoagulation and the normal cortical surface using a chopper direct-current amplifier and cathode ray oscillograph. Ischæmia was induced by a modification of the method of Opitz and Thorn[5]. After exposing the trachea, the neck of the rat is compressed by a rubber band. Although some blood still goes to the head through the spinal and vertebral arteries under these conditions, there is a characteristic decrease in cortical polarity with a half-time roughly equal to that after decapitation. From the time of compression artificial respiration was applied through the free trachea so that cardiac activity remained normal. After 10 or 20 min. the rubber band was released and the return of polarity observed. In various phases of repolarization animals were killed by immersion in liquid nitrogen. Glycogen[6], glucose[7], lactic acid[8] and creatine phosphate[9] were determined in the hemispheres.



(a) Time after end of ischæmia (min.)



(b) Time after end of ischæmia (min.)

Fig. 1. Changes of (a) glycogen (●—●), glucose (■—■), lactic acid (○—○) and (b) creatine phosphate (thin line) and cortical polarity (thick line) after 10 min. (full lines) or 20 min. (interrupted lines) ischæmia. Vertical dotted lines indicate standard error of the mean

At the end of the 10 min. of ischæmia, when cortical polarity had disappeared almost completely, glycogen, in agreement with the literature, was down to 52 per cent, glucose to 26 per cent and creatine phosphate to unmeasurable values, while lactic acid had risen to 411 per cent of the original value. During resuscitation these changes gradually disappeared. Complete repolarization of the cerebral cortex was attained already after 8–9 min., when the above metabolites were still considerably decreased (Fig. 1a). Statistical analysis of 75 correlated pairs of values for repolarization and creatine phosphate-levels shows a close correlation ($r = 0{\cdot}61 \pm 0{\cdot}07$). Renewal of the original creatine phosphate-level precedes that of cortical polarity by a fraction of a minute (Fig. 1b). From the above and from what is known about cerebral cortical metabolism it seems reasonable to assume that a causal relationship exists between the level of creatine phosphate and cortical polarity. Experiments with 20-min. ischæmia show that this correlation is not accidental. Repolarization under such conditions is much slower, but the correlation between the cortical steady potential and creatine phosphate-level remains unchanged.

The inability of other authors[10–13] to find a direct relation between creatine phosphate or adenosine triphosphate decrease and disappearance of spontaneous electroencephalogram activity or evoked potentials during anoxia or ischæmia, may be explained by the fact that these forms of cerebral activity are due to synaptic organization of neurones and the corresponding specific metabolism of brain mediators. The cortical steady potential, on the other hand, is a result of potential differences between various parts of the cell membrane of the cortical neurones sustained by active transport of ions. Renewal of polarity during resuscitation is not dependent, therefore, on a return of glycogen, lactic acid and glucose to normal levels, but rather on a restoration of creatine phosphate, or possibly of other high-energy phosphates serving as a direct source of energy for active transport through the cell membranes.

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Inward Movement of Calcium as a Link between Electrical and Mechanical Events in Contraction

Although there is every indication that the electrical events at the surface of cardiac and skeletal muscle fibres lead to the activation of the myofibrils within, there is as yet little definitive evidence as to the nature of the process linking these two events. Evidence showing that it is the depolarization of the fibre surface which is the electrical event responsible[1] has led many authors to suggest that the depolarization permits or promotes the entrance of a substance which then initiates the contraction. In particular, calcium ions have frequently been suggested as the substance responsible[2]. The recent demonstration by Hodgkin and Keynes[3] that there is an influx of calcium ions with each action potential in the squid giant axon has encouraged me to investigate the above hypothesis.

If there is an inward movement of calcium playing the part suggested above, it should be possible to eliminate the mechanical response of a skeletal muscle to electrical stimulation by soaking the muscle in a solution free of calcium. However, since this procedure makes skeletal muscle electrically inexcitable[4], another method was used. This consisted of studying the effect of soaking a skeletal muscle in a calcium-free solution for various periods of time on the contracture induced by a solution containing 25 m*M* potassium. The complicating effects on electrical excitability produced by changes in the concentration of calcium ions were eliminated by replacing 98 per cent of the sodium in the solutions with choline. All solutions contained 10^{-4} gm./cm.^{3} *d*-tubocurarine (Burroughs-Wellcome). The extensor digitis longis IV muscle of the frog was used because its small size (0·2–0·5 mm. diameter) allows rapid equilibration.

Typical responses produced by the excess potassium ions under the conditions specified are shown in Fig. 1*a* and *c*. Also shown are responses of the same muscle after treatment with the calcium-free solution. All mechanical recordings were produced under highly isometric conditions. After each response the muscle was placed in a solution containing the normal concentrations of potassium and calcium ions for 10–15 min. before another response was elicited. Each test, using calcium-free solutions, was preceded and followed by a control test. In these muscles the control responses remained essentially unaltered during 4–5 hr. of testing. The results obtained with two muscles are shown in Fig. 2. These represent the extremes obtained in about twenty muscles tested in this manner. Soaking in calcium-free solutions consistently inhibited the response, and, if continued for as long as 12 min., always completely eliminated the contracture induced by potassium ion. Similar results are obtained if an isotonic solution (123 m*M*) of potassium chloride is used to induce the contracture.

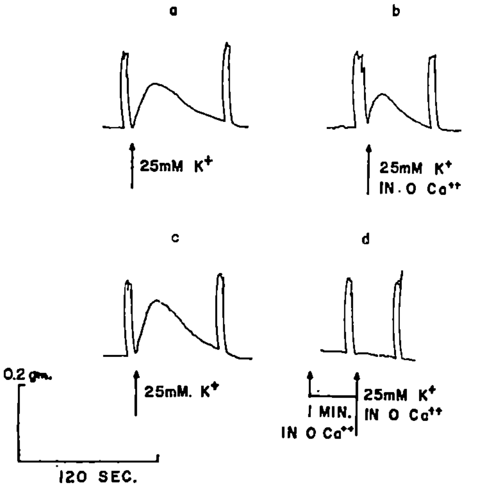

Fig. 1. Four successive contractures (*a*, *b*, *c*, *d*) produced during an experiment on a single muscle. *a* and *c* control responses. Large rectangular deflexions at start and end of contractures are artefacts produced by changing solutions in the bath

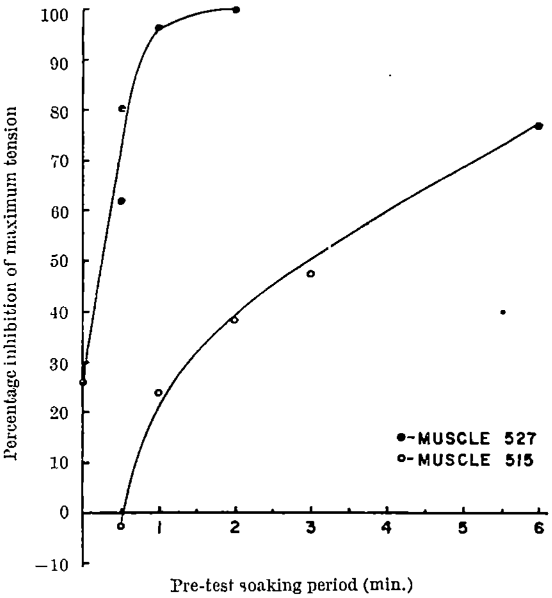

Fig. 2. Inhibition of the maximum isometric tension of the contracture induced by potassium ion due to pretreatment of the muscle with a calcium-free solution

That this change in the height of the contracture was independent of any change in the degree of depolarization produced by the excess potassium ion is shown in Fig. 3. The method of recording the depolarization is shown by the diagram in the lower part of the figure. The muscle was placed in a bath comprising two compartments which were isolated by a petroleum-jelly gap 8 mm. in length surrounding the muscle. The lines at the beginning of Fig. 3*A* and *B* indicate the potential difference between the two baths when they contained the same solution. The only change due to the calcium-free solution was a more rapid development of the depolarization induced by potassium ion. Maximum depolarization was the same in both records. In contrast, in most of the muscles tested, the maximum tension developed during the depolarization was 90–100 per cent inhibited by soaking for 5 min. in the calcium-free solution.

The above results demonstrate that soaking this skeletal muscle for short periods of time in a calcium-free solution inhibits the mechanical response of the muscle to a depolarization induced by potassium ion without changing the degree of depolarization. The short time necessary for this effect is in marked contrast to the long soaking periods for the removal of intracellular calcium[5], and strongly suggests that the effect is due to the removal of extracellular calcium. These results support the idea that ther is an inward movement of calcium ions when

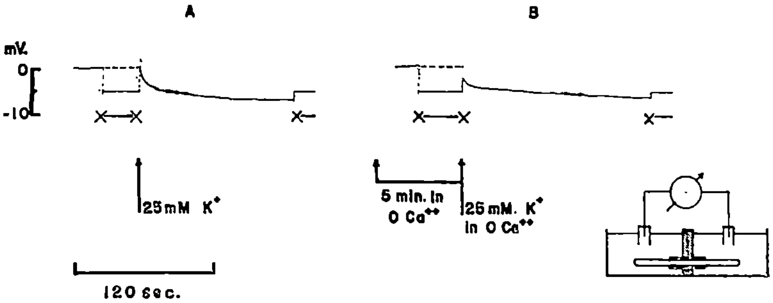

Fig. 3. Depolarizations produced by adding excess of potassium ions to the solution bathing a part of the muscle in one compartment of the bath. The recording instrument was turned off during the periods enclosed by the X marks (X—X) to permit the changing of the solution. The dashed lines are inked in continuations of the zero potential lines

muscle fibre is depolarized and that this calcium acts as a link between electrical and mechanical events in contraction.

In line with this work, Shanes and Bianchi have recently shown that there is an increased influx of calcium ions associated with action potentials and depolarizations induced by potassium ion in skeletal muscle (personal communication). Further details of this work, with evidence showing that the time course of this inhibition is determined by the rate at which calcium ions leave the extracellular space, will be published later elsewhere.

This work was supported by a grant from the National Research Council of Canada, to which I wish to express my thanks.

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Influence of Cysteamine on the Teratogenic Action of X-radiation

IT has been shown by Bacq and his collaborators[1] that the administration of cysteamine (β-mercaptoethylamine) is an extremely effective method of protecting adult animals against X-radiation. The present series of experiments were carried out in order to determine whether the administration of cysteamine to pregnant animals immediately prior to exposure to X-radiation had any value in the prevention of X-ray induced malformations in their young.

Table 1

Group	No. of dams	No. of young	Average weight of fœtus (gm.)	No. of young with meningocœle	No. of young with cleft palate
1 Radiation only	30	155	0·39	44 (38·4 per cent)	149 (96·1 per cent)
2 Radiation and cysteamine	27	163	0·59	4 (2·4 per cent)	144 (82·2 per cent)

Fifty-seven female mice of the Strong *A* line were used in these experiments. Only brother–sister matings were used throughout the experiment and the onset of pregnancy was determined by the presence of a vaginal plug, the day on which the plug was detected being taken as day 1 of the pregnancy. Two groups of animals were formed. Animals in both groups 1 and 2 received 300 r. whole-body radiation on day 12 of pregnancy. Animals in group 2 received in addition, by intraperitoneal injection, 4 mgm. of β-mercaptoethylamine hydrochloride dissolved in 1 ml. of physiological saline, 2–5 min. before the onset of exposure to X-radiation. On day 18 of pregnancy all the animals were killed. The young were removed from the uterus, weighed and examined for the presence of deformities.

Deformities encountered included syndactyly, micromelia, anophthalmia, hydrocephalus, meningocœle and cleft palate. The incidence of the last two malformations is shown in Table 1. There was a markedly lower incidence of all deformities with the exception of cleft palate in the group which received cysteamine (group 2).

From the findings of these experiments it is concluded that the administration of cysteamine to the pregnant animal considerably mitigates the deleterious effects of X-radiation on the developing fœtus. The significantly higher average fœtal weight in group 2 suggests a parallel with the observation of Bacq *et al.*[2] that cysteamine protects the adult animal against the fall in weight which follows exposure to high doses of X-radiation. On day 12 of pregnancy the sensitivity of the developing mouse palate to 300 r. X-radiation is at its height[3], whereas the sensitivity of the brain and skull has passed beyond the most acute phase. It is significant in this regard to note that the administration of cysteamine in the quantities used in these experiments was considerably more effective in reducing the incidence of meningocœle than that of cleft palate.

This work was supported by a grant from the Nuffield Foundation, which is gratefully acknowledged.

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Separation of Human Leucocytes from Blood

BECAUSE of the growing interest in the antigenic structure of human leucocytes, the need has arisen for a simple method of collecting pure suspensions of white cells, and for this reason the following method has been evolved.

Essentially, the technique comprises four stages. (1) The erythrocytes are encouraged to form rouleaux

Table 1. SHOWING THE SEPARATION OF LEUCOCYTES FROM WHOLE BLOOD

	Leucocytes				Erythrocytes			Leucocyte
	Volume (ml.)	Cells/mm.^{3}	Total cells × 10^6	Recovery (per cent)	Cells/mm.^{3}	Total cells × 10^6	Recovery (per cent)	Erythrocyte ratio
Whole blood	15	7,649 ± 79*	115·4	100	5,600,000 ± 79,700	84,000	100	0·0014
Supernatant (stage 1)	12	7,750 ± 150	93·0	81	7,000 ± 389	84	0·1	1·1
Sodium edetate suspension (stage 4)	5	4,562 ± 342	22·3	19·8	< 2·5	< 0·0125	< 0·000015	>1,800

* Standard error of mean.

by one of the published methods[1] and are allowed to sediment leaving the leucocytes in suspension. (2) The resulting suspension is placed as a shallow layer in a wide vessel to the bottom of which many of the leucocytes adhere. (3) The supernatant is discarded and the adherent cells washed free of erythrocytes with buffered saline. (4) The white cells are resuspended by gentle agitation in sodium edetate[2] ('Versene'; 'Sequestrene') dissolved in calcium- and magnesium-free buffer (solution *A* of Dulbecco and Vogt[3]).

Stage 1. Although we have used 'Dextraven' to sediment erythrocytes, it is probable that other methods would serve as well, provided that two considerations are borne in mind. First, the concentration of red cells must be reduced sufficiently to allow the leucocytes to become attached in stage 2 and, secondly, the concentration of white cells must be as high as possible. In practice, it has been found best to mix three volumes of blood treated with heparin with one volume of 6 per cent 'Dextraven' (Benger Laboratories, Ltd.) and to allow the mixture to stand in test-tubes for 1 hr. at room temperature. Suspensions obtained in this way contain 75–85 per cent of the leucocytes originally present with about an equal number of red cells. No advantage has been found in prolonging sedimentation or by sedimenting at other temperatures.

Stage 2. Much attention has been paid to the factors governing the attachment of leucocytes to surfaces. Although in early experiments white cells were allowed to adhere to glass which had been prepared for tissue culture, subsequent experience has shown that a greater proportion adhere to 'greasy' surfaces such as siliconed glass or 'vaspar' (equal parts of 'Vaseline' and paraffin wax). Provided that the latter surface is used, the proportion of leucocytes which adhere is unaffected by the concentration of plasma protein in the leucocyte suspension[5]. Using a layer only 2 mm. in depth we have found two factors to be of importance. First, the percentage of leucocytes that adhere to the surfaces during stage 2 varies directly with the concentration of those cells in the supernatant from stage 1. Secondly, the temperature is important because ten times as many intact cells were found at the end of stage 4 when leucocytes were allowed to become attached at 28° C. than when this step was carried out at 37° C. With the thin layers of fluid used, little advantage was noted when the period allowed for attachment was prolonged beyond 60 min.

Stage 3. The most important factor for obtaining leucocyte suspensions free from erythrocytes is thorough washing of the 'vaspar' surface; attached leucocytes seem able to withstand fairly vigorous shaking. In practice, three vigorous washes using each time at least the same volume of buffered saline as the original leucocyte suspension have been found to remove more than 99 per cent of the red cells. At this stage, examination of the adherent cells shows that these comprise 88 per cent polymorphonuclear cells, 6 per cent monocytes, 2 per cent eosinophils, 4 per cent small mononuclear cells thought to be degenerate polymorphonuclear cells and fewer than 0·1 per cent erythrocytes (Fig. 1). No lymphocytes were seen at this stage.

Stage 4. Virtually all the attached leucocytes may be removed from the 'vaspar' surface by gentle agitation with 1 : 10,000 sodium edetate for 15 min. at 37° C. Concentrations greater than this disrupt many of the cells, and lower concentrations fail to remove all the cells.

The technique at present used is as follows: A mixture of 3 parts of heparinized blood and one part of 6 per cent 'Dextraven' is placed in test-tubes and left at room temperature for 1 hr. Up to 20 ml. of the supernatant is then placed in a Roux bottle the sides of which have been coated with 'vaspar'. After leaving the bottle undisturbed on its side at 28° C. for an hour, the bottle is agitated and the fluid in it discarded. The adherent cells are thoroughly washed three times using 20 ml. buffer each time and 5 ml. 1 : 10,000 sodium edetate is run in and gently agitated for 15 min. at 37° C. The resulting suspension is then ready for use. The overall results of such a separation are given in Table 1, where it will be seen that about 20 per cent of the leucocytes originally present were recovered and the leucocyte–erythrocyte ratio rose from 0·0014 to more than 1,800; a purification of more than a millionfold.

Attempts have been made to assess the viability, the antigenicity and the purity of such white cell suspensions. Viability was assessed in three different ways. First, the proportion exhibiting dancing cytoplasmic granules[6] and the proportion thrusting

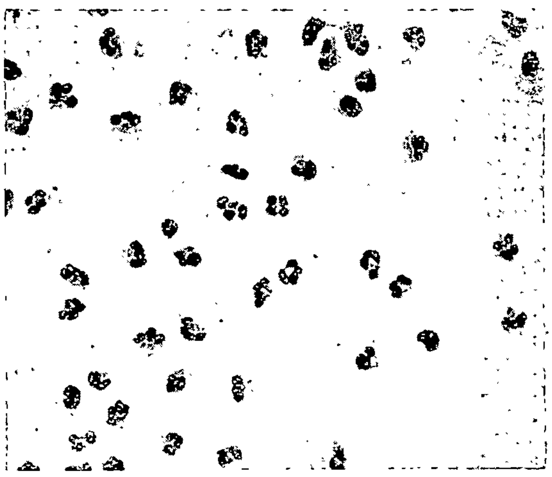

Fig. 1. Photomicrograph of a pure monolayer of leucocytes (stage 3). Leishman's stain. (× 280)

out pseudopodia, were determined by dark-field microscopy. Observation of 120 cells in the final suspension to which homologous serum had been added showed that 68 per cent possessed dancing granules and 64 per cent formed pseudopodia. Finally, phagocytosis of staphylococci by the leucocytes was studied. Although 80 per cent of the leucocytes appeared viable in these experiments there was difficulty in distinguishing between ingestion of the cocci and adherence to the surface of some of the cells. In fact, it seems possible that leucocytes remain sticky after viability is lost.

Antigenicity was shown by injecting a rabbit intravenously at weekly intervals with a million leucocytes/kgm. body-weight. It was found that serum taken ten days after the third injection and placed over a monolayer of leucocytes reduced the proportion of cells which exhibited dancing granules or formed pseudopodia. It also detached many cells from the glass and agglutinated them. None of these features was seen when serum taken from the same animal before immunization was used. White cell antibody was satisfactorily titrated by making a large number of replicate leucocyte monolayers of about a million cells each in slide cells (made by cementing 18-mm. stainless steel collars on to microscope slides with 'vaspar') and taking the separatory process up to the end of stage 3. Dilutions of serum were made in buffered saline, and 0·5 ml. of each was placed in a slide cell; these were incubated at 37° C. for 30 min. in a humid atmosphere. Each monolayer was then examined with a 2/3-in. objective. In control preparations the cells were still distributed as a monolayer attached to the glass while in immune serum detachment and agglutination were marked.

The method has the advantages that it is sensitive and simple to carry out, no human serum is present which might inhibit the antibody[1], the end-point is easy to determine and spontaneous clumping of cells does not interfere with the results. Using it we have found that serum taken before immunization had a titre less than 1 : 10, ten days after the third injection the titre was 1 : 1,280 and ten days after a further injection given at the sixth week the titre was 1 : 5,120. These three sera were titrated in parallel for red cell agglutinin by mixing the same dilutions with equal volumes of 2 per cent erythrocytes in buffered saline and reading microscopically after 30 min. The titres found were respectively $<1 : 10$, 1 : 20 and 1 : 160. Absorption of the last serum with erythrocytes reduced the red cell titre to less than 1 : 10 but left the white cell titre unaffected at 1 : 5,120. On the other hand, absorption with white cells reduced the white cell titre to 1 : 640 and the red cell titre to 1 : 40. These results suggest that this serum contained mostly white cell agglutinins and also antibodies specific for red cell and/or reacting with antigens shared by both cells[7]. Which of the last two possibilities were true might have been decided by mixed cell agglutination[8], but preliminary experiments have suggested that the phagocytic activity of leucocytes might give rise to mixed clumps of cells which would be mistaken for agglutinates.

It had been hoped to determine the purity of suspensions of white cells which were used as antigens by determining the nature of the antibodies produced. The preliminary studies mentioned above have failed to do this and the only criterion of purity that can be offered is that we have repeatedly obtained suspensions in which 2,000 to 3,000 leucocytes were consecutively counted without encountering a single erythrocyte and although they have not regularly been sought, platelets have not been found in final suspensions but have, on the contrary, been seen in large numbers in the suspension discarded during stage 3.

The method presented here of separating white cells from human blood combines a moderate yield with considerable purity and has the further advantages that spontaneous clumping does not occur and that cells remain viable and antigenic. Moreover, it may readily be adapted for titrating sera for leucocyte antibody. It is believed that the success of the method depends upon (*a*) avoidance of harsh procedures such as centrifuging and (*b*) the fact that the method selects only viable cells.

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Effect of Temperature on the Multiplication of Foot-and-Mouth Disease Virus in Suspensions of Kidney Cells of the Pig

Recently, Lwoff and Lwoff[1] showed that the development of the virus of poliomyelitis in *KB* cell cultures (cell strain from a human epidermoid carcinoma—H. Eagle), while occurring 'normally' at 37° C., is at least partially blocked at 39° C., only about 0·2–0·4 per cent of the virus at 37° C. being produced. They found the blockage to be reversible and considered that it occurred in a "late stage of the vegetative phase".

No results of studies on the multiplication of the virus of foot-and-mouth disease growing in tissue culture at temperatures above 37° C. have been published. Cartwright, Pay and Henderson[2] recently published growth curves for 37° C.

In the present investigation this virus growing in pig kidney cells has been used exclusively. Pig kidney monolayers were prepared by Sellers's method[3]. Virus was titrated by the method of plaque counts[4], on pig kidney monolayers and also by 50 per cent end-point determination in baby mice inoculated intraperitoneally[5]; both methods giving similar results.

The virus strains used were pig kidney culture strains of either *M*.11 (Type *O*) or of *C* 997 (Type *C*).

Virus, usually not exceeding 0·4 plaque-forming units per cell, was placed on pig kidney monolayers. After 30 min. incubation at 37° C. the supernatant was removed and the cell sheet washed with saline buffered with phosphate and then treated with versene for 12–20 min. The resultant cell suspension was centrifuged at low speed, and after two washes in culture medium resuspended in this medium to give roughly 2×10^5 cells/ml. This suspension, after gassing with 5 per cent carbon dioxide in air, was incubated with continuous shaking in Carrel flasks in water-baths thermostatically controlled with a maximum fluctuation-range of 0·25 deg. C. Strict control of temperature has so far not been possible during the 75-min. preparation preceding this stage.

For each test two samples were withdrawn. The first was immediately diluted 1 : 10 in saline buffered with phosphate and served for 'whole-culture' titration. Three components make up this 'whole-culture' titre : unadsorbed infectious virus ; infected cells containing infectious virus not yet released into the supernatant ; and infected cells containing no infectious virus, but potentially capable of forming it if incubated further (eclipse phase). The second sample was immediately centrifuged and the supernatant titrated. Any infectivity detected was due to unadsorbed infectious virus, though occasionally a few infected cells may also have contributed. The cell pellet was disintegrated by the addition of a 1 per cent solution of sodium dodecyl sulphate. This detergent does not affect the infectivity of the virus yet disrupts the cells in a matter of seconds[6]. Suitable dilutions of the sample treated with sodium dodecyl sulphate were then titrated. Any infectivity found must be due to infectious virus which is 'cell associated', that is, infectious virus attached to or in the cells at the moment of treatment with the detergent. In certain cases where unadsorbed virus was present in the supernatant, a trace of this virus could also be present in the sample. No contribution is made by the disrupted eclipse-phase cells.

Virus multiplication was studied at temperatures of 35·0, 37·1, 39·6, 41·1, 41·7, 42·1, 42·6, 43·6 and 45·0° C. The period during which the infective virus titre increased, and the total increase in titre, was approximately the same at 35·0, 37·1 and 39·6° C. (in the same experiments). With increasing temperature, while the period of increase in titre seemed to be of about the same duration, the total increase in titre fell off rapidly : at 41·1° only about 50 per cent of the total at 39·6°, at 41·7° 5–10 per cent, at 42·1° less than 0·5 per cent, and at 42·6° and 43·6° C. no infectious virus at all was detected (Table 1). Thus the amount of infectious virus formed was reduced at temperatures between 41° and 42° C. and complete blocking of successful virus multiplication occurred at temperatures above 42·6° C. At 45° C. the infected cells, though surviving for 45 min., had all disappeared 90 min. later.

Table 1. VIRUS MULTIPLICATION AT TEMPERATURES ABOVE 39·6° C. Results from three experiments titrated on pig kidney monolayers. Titres given to the nearest 0·1 $\log_{10}$ unit per 0·4 ml. of suspension

Time after absorption (min.)	Sample	Temperature (° C.)						
		39·6	41·1	42·6	43·6	41·7	42·1	45·0
75	*wc*	3·3	3·3	3·3	3·3	3·3	3·3	2·9*
	sds	< 1·0	< 1·0	< 1·0	< 1·0	< 1·0	< 1·0	< 1·0
150	*wc*	3·3	2·9	3·2	3·1	2·8	2·3	2·2
	sds	< 1·0	< 1·0	< 1·0	< 1·0	< 1·0	< 1·0	< 1·0
180	*wc*	3·7	3·2	3·2	3·0	3·0	3·0	
	sds	4·2	3·6	< 1·0	< 1·0	1·6	< 1·0	
210	*wc*	4·4	3·9	2·8	3·0	3·3	2·6	
	sds	5·0	4·0	< 1·0	< 1·0	3·0	1·3	
240	*wc*							< 1·0
	sds							< 1·0
270	*wc*	5·0	4·4	2·3	2·7	3·8	2·7	
	sds	4·8	4·6	< 1·0	< 1·0	3·3	2·7	
330	*wc*	5·1	4·5	2·5	2·5	3·5	2·7	
	sds	4·8	4·0	< 1·0	< 1·0	3·0	—	

wc, Whole-culture sample ; *sds*, sodium dodecyl sulphate-treated whole-culture sample.

* Transferred to 45·0° at 105 min.

As no infectivity was detected at any time in the samples treated with sodium dodecyl sulphate or in the supernatant at 42·6° and 43·6° C. (and also at all temperatures tested at 1½–2½ hr.) it follows that infectious virus amounted to less than 100 plaque-forming units (P.F.U.) per 4 ml. of suspension. Indeed, further experiments not included in the table showed that if infectious virus was present at all, it was less than 1 P.F.U. per 4 ml. Yet the same suspensions titrated as 'whole culture' contained more than 10,000 P.F.U. in the same volume. Thus comparisons of the curves for the 'whole-culture' with those for samples treated with the detergent (and with those for the supernatant) showed that at certain times in this system, and under these conditions of low multiplicity of original infection, all the detectable infectivity in a culture-sample resides in the *intact* cells which are presumed to contain virus in the eclipse phase ; that is in such a state that it cannot be extracted as infectious virus by means shown to be capable of extracting such virus. All virus appears to enter the eclipse phase soon after infection. The eclipse phase at 39·6° C. ended between 160 and 170 min. when virus infectivity first appeared in the sample treated with sodium dodecyl sulphate.

The blocking of virus multiplication at 42·6° and 43·6° C. is reversible and affects a late stage in virus growth : a late stage because transfer of infected cells incubated at 39·6°–42·6° C. up to 150 min. after initial infection, that is, within 10–20 min. from the normal end of the eclipse phase, completely blocked the production of infectious virus. Reversibility was demonstrated by transfer of the virus cell system from 42·6°—39·6° C. after varying periods of incubation at 42·6° C. Such transfer results in the formation of infectious virus. However, the virus cell system seems to be altered, for although infectious virus was demonstrated within 30 min. of retransfer to 39·6° C., the period of increase in virus titre after such transfer was about three times longer than the corresponding 'normal' period at 39·6° C. Clearly, the temperature block altered the balance of the virus – cell system in such a way that its effects persisted at least for some considerable time after removal of the blocking effect. There is also some indication that on retransfer to 39·6°, after several hours incubation at 42·6° C., less virus is produced per infected surviving cell.

Infected cells could be held for at least 36 hr. in the eclipse phase by incubation at 42·6–43·6° C. It is of interest in this connexion that the death-rate of eclipse-phase cells at 42·6° C. is about 90 per cent in 8 hr., while that of free virus in the supernatant fluid (*p*H 7·6) is more than 99·9 per cent.

It should be stressed that what is reported here refers only to virus – cell systems in which the multiplicity of infection per cell was of a low order. It was found that initial infection with greater multiplicities of virus led to the detection of some cell-associated infectious virus throughout the normal eclipse phase and also for many hours of the temperature-prolonged eclipse phase.

These observations indicate that by the combined use of the temperature blocking effect on an appropriate virus – cell system and sodium dodecyl sulphate for extraction of infectious virus it should be possible to obtain further information on virus absorption and penetration and on succeeding stages of the multiplication process of the virus of foot-and-mouth disease.

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Effects of Potassium and Sodium Ions on the Resting and Action Potentials of the Giant Axon of the Cockroach

A knowledge of the fundamental properties of the insect nerve is very useful in studying the mode of action of insecticides, many of which are nerve poisons. In order to verify the validity of the sodium theory[1] in the cockroach giant axon[2], the effects on the resting and action potentials of varying the sodium and potassium concentrations in the bathing fluid were examined with intracellular micro-electrodes. A compensation circuit for improving high-frequency responses was employed in place of the simple cathode follower circuit used in our previous study[3]. The following mean values for the membrane potentials were obtained from axons immersed in modified Ringer's solution containing sodium ions at a concentration of 214 m*M*: resting potential 70·3 mV.; action potential 94·5 mV.; positive phase 3·4 mV.; maximum rate of rise of action potential 1,113 V./sec.; maximum rate of fall 382 V./sec.

Varying the external potassium concentration had a similar effect on the resting potential to that with other animals. Plotting the resting potentials against the logarithms of the external potassium concentrations resulted in a straight line in the higher concentration ranges. A decrease in the external sodium concentration had no appreciable effect on the resting potential, but it effectively depressed the action potential and eventually caused the axon to become inexcitable. The straight line for reversed potentials/log sodium concentrations diverged only slightly from the theoretically expected straight line having a slope of 59 mV. for a tenfold change in sodium concentration. Furthermore, when the axon came into contact with the solution deficient in sodium the rate of rise of the action potential was decreased more effectively than the rate of fall and the magnitude of the action potential. This behaviour of the cockroach axon in solutions of low sodium content is quite similar to that of the giant axon of the squid[4]. It can safely be said that the overall result constitutes strong evidence for the essential validity of the sodium theory in the giant axon of the cockroach.

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Synaptic Transmission in the Cockroach

Although the synaptic transmission across the last abdominal ganglion of the cockroach has been studied by several workers[1–3], the knowledge obtained so far seems to be less complete than for synapses in vertebrate animals. In the present investigation electrical phenomena associated with the synaptic transmission across this ganglion were analysed with special reference to the nature of the synaptic transmitter. The cercal nerve–nerve cord preparation was isolated[4], and postsynaptic responses were led off from the origin of the connectives from the last abdominal ganglion.

A presynaptic volley set up excitatory postsynaptic potentials. When these reached a certain critical level, propagated action potentials were generated. Excitatory postsynaptic potentials could be observed more easily by employing pharmacological agents such as urethane and phenobarbital. These substances depressed the discharge of impulses from the ganglion cells, keeping the potentials observable.

An application of anticholinesterases such as eserine, tetraethyl pyrophosphate and parathion caused a marked increase and prolongation of the excitatory postsynaptic potentials with a prolonged after-discharge superimposed (Fig. 1,*A* and *B*). The excitatory potentials grew so markedly that a persistent ganglionic depolarization associated with a synaptic block was eventually produced. Repolarization associated with a recovery of synaptic transmission occurred after some time. Alternate depolarization and repolarization might occur without presynaptic stimulation. By employing urethane or phenobarbital it was clearly demonstrated that the anticholinesterases caused the ganglion to give a very prolonged excitatory postsynaptic potential with no discharges superimposed (Fig 1,*C*–*F*). Furthermore, it was found that the inactivation of cholinesterase after dosage with the anti-cholinesterases ran parallel with after-discharge.

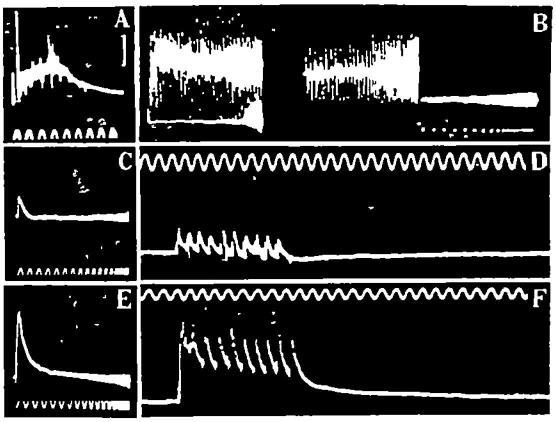

Fig. 1. Effects of eserine on postsynaptic responses. A voltage calibration of 0·5 mV. is applied to all records. Time markers are 50 c./s. except for *B*, which is 25 c./s. (*A*) Before treatment. A postsynaptic response evoked by a single presynaptic volley. A brief after-discharge. 14° C. (*B*) as in (*A*) but 47 min. after treatment with $5 \times 10^{-5} M$ eserine. A prolonged ganglionic depolarization superimposed with discharges. Time intervals between successive records are 15 sec. All records are arranged on the same base line. (*C*) An excitatory postsynaptic potential set up by a single presynaptic volley. Under $2 \times 10^{-2} M$ urethane 22° C. (*D*) as in (*C*) but by repetitive volleys. (*E*) as in (*C*), but 17 min. after treatment with $10^{-5} M$ eserine. An augmented and prolonged excitatory postsynaptic potential. (*F*) as in (*D*), but 41 min. after treatment with $10^{-5} M$ eserine. Augmented and prolonged excitatory postsynaptic potentials

When applied to the intact ganglion, the threshold concentration of acetylcholine for discharging impulses was as high as $10^{-2} M$. With the eserinized or desheathed ganglion, this was lowered to $10^{-3} M$. When the desheathed ganglion was eserinized, it was lowered to $10^{-4} M$; although it was still about one hundred times as high as for vertebrate ganglia and skeletal muscles.

With regard to transmitter substance in the last abdominal ganglion of the cockroach, three possible explanations are suggested on the ground of the present study.

(1) Acetylcholine may be a transmitter. However, since the susceptibility of subsynaptic membrane to acetylcholine is relatively low, it is necessary for acetylcholine to be stored and liberated in large amounts and for the cholinesterase to have a high activity. A high acetylcholine content and a high cholinesterase activity are known to be the case in the cord of the cockroach.

(2) Acetylcholine may be a transmitter. However, since a certain barrier around nerve cells prohibits the penetration of applied acetylcholine, the threshold concentration is high even after desheathing and eserinizing the ganglion.

(3) The synaptic transmitter may not be an acetylcholine-like substance. The prolongation of the excitatory postsynaptic potential following treatment with anticholinesterases suggests that the transmitter is a certain ester hydrolysed by cholinesterase.

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In vitro Incorporation of Serine labelled with Carbon-14 into Mitochondrial Phospholipids

LITTLE is known about the biosynthesis of phosphatidyl serine. It has been suggested that the biosynthetic pathway of this phospholipid might be similar to that of phosphatidyl choline and phosphatidyl ethanolamine[1]. The present investigation describes the incorporation of uniformly labelled L-serine-^{14}C into the phospholipids of rat liver mitochondria and some of the co-factors required for this process.

The mitochondria were prepared by homogenizing rat livers in ten volumes of ice-cold 0·25 M sucrose containing $2 \times 10^{-3} M$ ethylenediamine tetraacetic acid, pH 7·4. Cell fractions were obtained by the usual fractional sedimentation[2]. The mitochondrial fraction was then washed once with the original volume of 0·25 M sucrose and finally suspended in 0·25 M sucrose (1 ml. per gm. wet weight of liver tissue). 1·5 ml. of mitochondrial suspension were incubated for 1 hr. at 37° with L-serine-^{14}C and various co-factors as outlined in Table 1. The reaction was stopped by the addition of 1/10 volume of 50 per cent trichloracetic acid. The precipitate was washed extensively with 5 per cent trichloracetic acid containing $2 \times 10^{-3} M$ D,L-serine. The extraction of the phospholipids from the trichloracetic acid precipitate, their separation from other lipids and pigments on silicic acid columns and the determination of their specific activity by means of liquid scintillation counting was carried out, as will be described elsewhere.

Table 1. Each system contained: 1·5 ml. mitochondrial suspension in 0·25 M sucrose, 0·25 ml. of 1·25 M sucrose, 0·4 ml. of 0·1 M phosphate buffer (pH 7·4), 0·2 ml. of 0·2 M magnesium chloride and 5 μM of L-serine (0·5 μc.). After the addition of co-factors as indicated below, the final volume was adjusted with distilled water to 3·0 ml. Time of incubation was 60 min.

Exp.	Co-factors added (μmoles)	Specific activity (disint./min./mgm. phosphate)
1	None*	77
	None†	335
	None	1,420
	ATP (10)	2,640
	ATP (10) + CTP (2·5)	1,380
	ATP (10) + CoASH (1)	7,220
	CMP (5)	12,900
2‡	None	1,290
	CMP (5)	5,040
	CMP (5) + ATP (10)	8,660
	CMP (5) + ATP (10) + CTP (2·5)	4,810
	CMP (5) + ATP (10) + CoASH (1)	25,050

* The reaction was stopped after 0 min. of incubation.

† In this experiment the mitochondrial suspension was boiled for 5 min. prior to incubation; the system contained 10 μmoles of ATP.

‡ In experiment 2 only 2 μmoles of L-serine were added (0·2 μc).

ATP, adenosine triphosphate; CTP, cytidine triphosphate; CMP, cytidine monophosphate; CoASH, reduced coenzyme A.

As can be seen in Table 1, cytidine monophosphate, adenosine triphosphate and reduced coenzyme A all increased the incorporation of L-serine into the mitochondrial phospholipids. Cytidine triphosphate, however, which is known to be required for the incorporation of phosphoryl choline or phosphoryl ethanolamine into the corresponding phospholipids[1], did not bring about an increase in the rate of incorporation. In fact, cytidine triphosphate suppressed the increased incorporation due to the addition of adenosine triphosphate (Exp. 1). The increased incorporation due to adenosine triphosphate plus cytidine monophosphate was partly inhibited by the addition of cytidine triphosphate (Exp. 2). Since the concentration of adenosine triphosphate was the same in both these experiments, it would seem that cytidine monophosphate and cytidine triphosphate are antagonistic. These results also show that the marked increase in the rate of incorporation due to cytidine monophosphate cannot be explained by transphorylation reactions forming cytidine triphosphate from cytidine monophosphate.

The combination of the co-factors cytidine monophosphate plus adenosine triphosphate plus reduced coenzyme A yielded an increased incorporation which was greater than the sum of those brought about by either cytidine monophosphate, or by adenosine triphosphate plus reduced coenzyme A. This result suggests that all three co-factors might act in a common pathway. Further experiments showed that the optimal concentration of cytidine monophosphate was found to be $3 \cdot 3 \times 10^{-3} M$, and that it could not be replaced by other 5′-mononucleotides. The optimal pH of the overall reaction was near 7·5. Magnesium ions ($12 \times 10^{-3} M$) increased the incorporation of L-serine in the presence of cytidine monophosphate plus adenosine triphosphate plus reduced coenzyme A, whereas calcium and fluoride ions were shown to be strongly inhibitory at the same concentration.

The radioactive phospholipid was identified by mild alkaline hydrolysis of the total phospholipids followed by separation of the resulting glycerylphosphoryl diesters on ion-exchange resins[3]. 95 per cent of the total radioactivity eluted from the resin column was found to be in the glycerylphosphoryl serine fraction, the remaining activity being in the glycerylphosphoryl ethanolamine fraction.

A more detailed report of this work will be published elsewhere.

We wish to thank Prof. A. C. Frazer for his interest and encouragement. Our thanks are also due to Miss C. Bentham for technical assistance. This work was supported by grants from the Medical Research Council.

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Distribution of Tissue-Specific Antigens in Centrifugal Fractions of Rat Liver

The microsome fraction of rat liver parenchymatous cells has been shown to contain tissue-specific antigens[1,2]. These antigens are gradually lost from the cell during the course of carcinogenesis, the hepatoma cell being virtually devoid of them[3,4]. Thus they constitute an important difference between normal and cancer cells and offer a possibility for investigating the mechanism of de-differentiation that is linked with the property of uncontrolled growth. This communication is concerned with the identification of the subcellular structures which are involved in the immunological change.

Well-defined nuclear, mitochondrial and microsomal fractions were isolated from rat liver homogenates by the methods developed by de Duve[5]. Antimicrosomal sera were prepared in rabbits and made specific for the reaction with liver by heterologous absorption with kidney microsomes[4]. The quantitative precipitin method was used for the immunological tests.

The tissue-specific microsomal antigens in the nuclei and mitochondria were determined by measuring the antibody-binding capacity of these fractions. They were incubated with the antiserum, centrifuged, and the supernatant was tested for antibody by equivalence-point determination with microsomes as antigen. No measurable amount of antibody was removed from the specific serum by the mitochondrial fraction, and the antibody-binding capacity of the nuclear fraction was about 10 per cent that of the same amount of microsomes expressed in μgm. protein nitrogen. Thus the tissue-specific antigens of the microsomes appear to be confined to this fraction only, the residual activity of the nuclei probably being due to microsomal contamination.

Table 1. Microsomal Subfractions

	Particle size*	Protein content as percentage of that of untreated microsomes	Ribonucleic acid content as percentage of that of untreated microsomes	Ribonucleic acid content as percentage of ribonucleic acid plus protein	μgm. phospholipid phosphorus per mgm. protein nitrogen
Untreated microsomes	350	100	100	11·2	138
Fraction *M*	350	58	17	3·2	163
Fraction *RNP*	40	24	69	30	75
Fraction *S*	Supernatant	18	14	7·5	20

* Expressed in Svedberg units of the smallest particles sedimented under the conditions applied.

The microsomal material can be further fractionated into the constituents of the endoplasmic reticulum from which it is derived. Three fractions were obtained by suspending microsomes in a medium composed of 0·25 *M* sucrose, 0·08 *M* sodium citrate, and 0·01 *M* phosphate buffer *p*H 7·2 and subsequent differential centrifugation. Their characteristics are shown in Table 1. Fraction *M* represents the membranes of the endoplasmic reticulum, and contains most of the proteins and the lipids of the microsomes. Fraction *RNP* consists largely of the ribonucleoprotein particles of the endoplasmic reticulum. Membranous material is still present, however, as indicated by the lipid content. The final supernatant *S* includes proteins which are brought into solution by the citrate medium, presumably the contents of the microsomal vesicles.

Comparative equivalence-point determinations were performed with the three fractions, as well as with the untreated microsomes, against a fixed volume of tissue-specific antiserum. Material containing larger amounts of the particular antigen reached the equivalence point at comparatively lower concentrations. In these experiments it was found that the antigenic activity is highest in fraction *M*, less in untreated microsomes and still less in fraction *RNP*. Fraction *S* was completely inactive in the precipitin tests. Fig. 1 shows a comparative equivalence-point determination of fraction *M* and untreated microsomes, illustrating the difference in antibody-binding capacity of the two preparations which indicates that the material removed by the citrate extraction is antigenically largely inert.

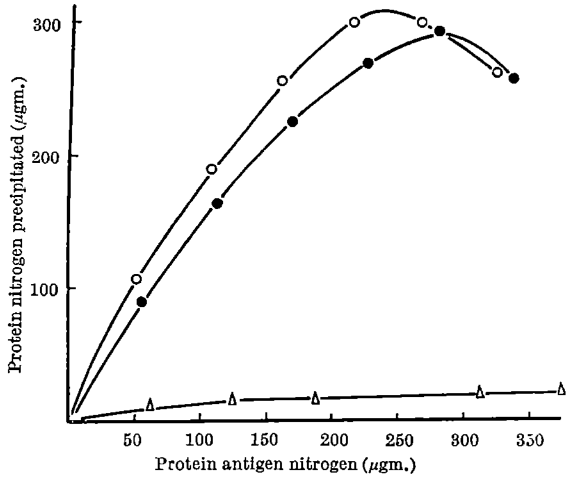

Fig. 1. ○—○, Fraction *M*; ●—●, untreated microsomes; △—△, kidney microsomes

There is a correlation between the antigenic activity of microsomal subfractions and their lipid content. If the latter is taken as a measure for the membranes of the endoplasmic reticulum this suggests that the tissue-specific antigens, probably lipoproteins, are located in these membranes.

In 48 hr. regenerating rat liver the ratio of ribonucleoprotein particles to membranes is changed by an increase of the amount of ribonucleoprotein particles[6,7]. Microsomes of such a tissue should then contain less of the specific antigens per protein weight as compared with microsomes from normal liver. This could be confirmed by equivalence-point determination.

This localization of tissue-specific substances which are known to disappear during carcinogenesis underlines the importance of organized cytoplasmic reticular structures for the state of differentiation[8]. Recent data on microsomes in cancer tissue can be correlated on the basis of the results presented above. Electron micrographs of sections from rat liver tumours induced with *p*-dimethylaminoazobenzene show only very few apparently randomly distributed membranous elements in the cytoplasm[8,9]. Glucose-6-phosphatase, an enzyme known to be bound to the endoplasmic reticulum membranes[10], is not present in the hepatoma[11]; furthermore, the phospholipid content of the microsomes is reduced[12].

On the other hand the amount of ribonucleoprotein particles is increased in the liver tumour[13]. The loss of the swelling ability of the microsomes obtained from malignant tissue[14] is best explained by an alteration in the microsomal membranes. In the normal liver parenchymatous cell the endoplasmic reticulum exhibits a high spacial organization with numerous interconnected vesicles[15]. These structures provide "conditions of semi-isolation"[16] for certain complex enzyme systems and might thus exert a regulating influence upon them. Degradation of the lamellar barriers in the course of carcinogenesis establishes free access for metabolic products and enzymes to every part of the cytoplasm, and in this way seems to contribute to the uncontrolled turnover activity of the cancer cell.

I wish to express my indebtedness to Prof. Friedrich-Freksa for his generous guidance and constant support. The financial aid of the Studienstiftung des deutschen Volkes is gratefully acknowledged. This investigation is being continued and will be published in full elsewhere.

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An Effect of Glucose on Bacteriophage Synthesis in *Salmonella typhimurium*

A MUTANT of *Salmonella typhimurium* has been obtained by Engelsberg (unpublished) which was characterized as 'diauxie-resistant' since, in contrast to the wild type, it could adapt itself to normally inducing substrates in the presence of glucose. The mutant was found by Engelsberg and Entner (unpublished) to contain three times as much glucose-6-phosphatase as the wild type. This enzyme difference suggests that the diauxie phenomenon can be explained by an extension of the hypothesis of Racker *et al.*[1] concerning the Crabtree effect, where it was suggested that glucose inhibits the utilization of endogenous materials by competing for the phosphate-nucleotide (adenylate) pool.

The present communication shows that an analogous glucose effect can be extended to bacteriophage synthesis. Glucose[2], bacteriophage infection[3], chloramphenicol[4], and amino-acid analogues[5] inhibit the induced synthesis of adaptive enzymes. Recently, it has been shown by Bertani[6] that during infection of some bacteria with certain temperate phages, the "selective inhibition of protein synthesis" by addition of chloramphenicol or amino-acid analogues causes a lysogenic response to be favoured over a lytic one.

With a multiplicity of infection much less than it can be demonstrated that when wild type *typhimurium* is infected with phage *P*22 (one of host-parasite pairs studied by Bertani), the presence of glucose also affects the course of infection in such a way as to favour the lysogenic response (Table 1). Under the same conditions but in the absence of glucose, a lytic response occurs. As might be predicted, the diauxie-resistant mutant is lysed either in the presence or absence of glucose.

Table 1. COURSE OF PHAGE *P*22 INFECTION IN *S. typhimurium* IN THE PRESENCE AND ABSENCE OF GLUCOSE (50–100 PHAGE ADDED PER PLATE)

	Lytic response (per cent)	Lysogenic response (per cent)
Wild type		
With glucose		100
No glucose	100	
Diauxie-resistant mutant		
With glucose	100	
No glucose	100	

In the experiments the method of Adams[7] was used to obtain infection responses. To 10^8 bacteria in 2 ml. of nutrient broth containing 0·7 per cent agar (45° C.) were added 50–100 bacteriophage, and the mixture was immediately shaken and poured on top of previously solidified nutrient agar plates. Glucose when present was added to a concentration of 1 per cent just prior to addition of phage. The lytic response is shown in Fig. 1*A* and lysogenic response in Fig. 1*B*. The papillæ in the centre of the halos in Fig. 1*B* can be shown to be lysogenic clones by use of the standard method of re-streaking isolated clones until free of phage and subsequent induction of phage synthesis by ultra-violet exposure. It should be pointed out that lysogenic bacteria can be also isolated from the centre of lytic plaques, but these are lysogenized through high multiplicity of infection many cycles after the initial lytic response[8].

It would appear plausible from these experiments that glucose and bacteriophage chromosome compete for the phosphate-nucleotide pool at common sites

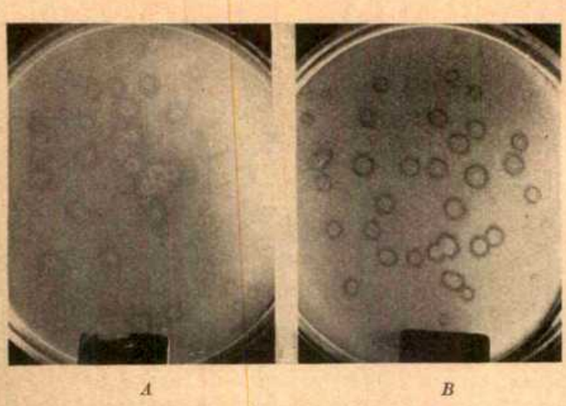

Fig. 1

involved in protein synthesis. A virulent phage, among other things, perhaps competes more successfully for this pool than a temperate phage. In wild type *S. typhimurium* cells, glucose, by having a greater affinity for the phosphate-nucleotide pool than phage chromosome, would inhibit phage protein synthesis as it does adaptive enzyme synthesis and the use of endogenous material. Lysogeny then results. The high glucose-6-phosphatase content of the diauxie-resistant mutant allows for the continual regeneration of the phosphate-nucleotide pool, and neither adaptive enzyme nor phage protein synthesis (with resultant lysis) is inhibited by glucose. These possibilities are being further investigated.

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Identity of the Tetanus Toxin Receptor in Nervous Tissue

TETANUS toxin is thought to act by suppressing synaptic inhibition[1], and presumably it acts upon some substance at the inhibitory synapses in the grey matter of nervous tissue. As a possible approach to discovering the nature of this substance, the well-known Wassermann–Takaki phenomenon[2], that is, the fixation of tetanus toxin by the grey matter of nervous tissue, has been re-investigated.

Landsteiner and Botteri[3] showed that the water-insoluble sphingolipid fraction of brain had the greatest toxin-fixing capacity and believed that the cerebroside, phrenosine, was the specific toxin receptor substance; but they could not reconcile this with the fact that white matter is much richer in phrenosine than grey matter. It has now been shown that when sphingolipid suspensions are added to solutions of crude tetanus toxin, and of several other toxins, enzymes and other proteins, only the tetanus toxic protein is fixed. When the toxin is spun down with the sphingolipid, and the sphingolipid–toxin complex washed, the protein can be dissolved in alkali and estimated by the method of Lowry *et al.*[4]. It was found that 1·91 μgm. of protein was adsorbed for each $L+$ unit of toxin; this is in good agreement with the value of 2·02–2·15 μgm. protein per $L+$ unit for the pure crystalline toxin obtained by Pillemer *et al.*[5].

This specific adsorption of protein was used as the basis of an assay of the receptor. It was shown that when phrenosine was sufficiently purified it no longer fixed the toxin, and the receptor was evidently a contaminant. When crude phrenosine was partitioned between the two immiscible phases of a solvent system consisting of 15 parts chloroform, 15 parts benzene, 23 parts methyl alcohol and 7 parts water[6], little or no receptor activity could be recovered from either phase, but full activity was recovered when the two phases were recombined. Phrenosine, mixed cerebrosides or sphingomyelin could be substituted for the lower phase component. The upper phase component was found to a greater extent in grey matter than in white, was water-soluble, and on treatment with Bial's reagent yielded a pigment absorbing maximally at 570 mμ. In these properties it resembled the mucolipids[7] (ganglioside[8], strandin[9]), and it was found that both ganglioside and strandin could be substituted for the upper phase component.

The water-soluble mucolipids form complexes with the water-insoluble cerebrosides and sphingomyelins, which tend to be soluble in water when they contain excess mucolipid, but insoluble when calcium is incorporated in the complex. Unless the receptor were insoluble in water it could not be detected by the methods employed up to this stage, which depended on spinning down the receptor-toxin complex at 5,600*g*. However, it was found that when tetanus toxin (molecular weight[10] 67,000) and water-soluble mucolipid (molecular weight[7,9] 180,000–250,000) were mixed in solution and centrifuged at 114,400*g* for 2 hr., 84 per cent of the mucolipid and 82 per cent of the toxin in the upper half of the centrifuge tube migrated to the lower half, whereas only 29 per cent of the toxin migrated in the control tube containing toxin alone. Evidently the specific fixation is between the toxin and the mucolipid.

A detailed account of this work will be published in the *Journal of General Microbiology* (**20**, No. 2; 1959).

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Loss of Sodium from the Skin of the Dehydrated Toad, *Bufo marinus*

THE movement of sodium across the skin of frogs and toads has been studied extensively[1]. *Bufo marinus* placed in distilled water loses sodium from the skin at an increased rate when injected with large doses of 'Pitressin'[2]. Increase in concentration of the body fluids as in dehydration potentiates posterior pituitary hormone release in mammals, and the same appears to be the case in amphibians[3]. Therefore it was of interest to see what effect such endogenous release of posterior pituitary hormone had on loss of sodium from the skin.

The loss was measured in normally hydrated toads during a 1-hr. period on three successive days. At the beginning of each measurement they were catheterized, thoroughly washed in distilled water and then placed in 150 ml. of this water for 15 min., rinsed again and finally replaced in 150 ml. of fresh distilled water. At the end of 1 hr. a sample of the fluid bathing the toads was taken and the sodium concentration determined with an EEL-flame photometer. The total loss of sodium was then calculated from the known volume of fluid bathing the toad. Apart from the experimental periods, the toads were kept in tap water. Care in handling ensured that urine was not voided while the measurements were being made. In a second series of experiments the same toads were left without water for 48 hr. at 21° C. and 55 per cent relative humidity during which time they lost 30·0 per cent (S.E. ± 1·25) of their body-weight—a degree of dehydration from which they readily recovered if replaced in water. At the end of this period loss of sodium from the skin was measured as before.

Table 1. LOSS OF SODIUM (MGM./HR.) FROM THE SKIN OF *B. marinus* UNDER NORMAL CONDITIONS AND DURING HYDRATION

Normal			Dehydrated
Day 1	Day 2	Day 3	
0·0516 ± 0·00336	0·0533 ± 0·00391	0·0582 ± 0·01232	0·3352 ± 0·06792

The results are the means ± S.E. in the same group of 15 toads (mean weight, 84·49 ± 2·800 gm.). Normal values all differed significantly from the dehydrated ($P < 0·001$).

The results are given in Table 1. It can be seen that the normal day-to-day rate of loss of sodium is remarkably constant, while in the previously dehydrated toads there is a marked increase in loss of sodium. The rate of loss is about four times as rapid as in *B. marinus* injected with large doses of 'Pitressin'[2]. The discrepancy may be due to a change in the concentration ratio across the skin and/or a change in the properties of the skin itself or to a greater effectiveness of endogenous hormone. In this latter respect it has shown that in *Bufo bufo* uptake of water is not as rapid after even supramaximal doses of posterior pituitary extracts as it is after the animals have been dehydrated[4].

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Bathyscaphoid Squid

BUOYANCY equilibrium, or being of the same density as sea water, can confer a great economy of effort upon free-swimming animals and is approached or achieved in a variety of ways. While investigating buoyancy problems during a cruise of the Plymouth laboratory's research vessel *Sarsia* in the southern Bay of Biscay we found a particularly striking adaption in certain mid-water squid. Although some of the oceanic species resembled the coastal forms in being denser than sea water, the majority of the mid-water forms caught were in buoyancy equilibrium. Having neither cuttle-bone nor air sac they must have some other component less dense than sea-water (density = 1·026) to counterbalance the tendency of their proteins to sink.

These mid-water squid had enormous body cavities filled with fluid[1]. When the fluid, and it amounted to two-thirds of the squid's volume, was drained the squid sank; this showed that the buoyancy of the intact animals was given by the low densities of their coelomic fluids. From the volumes of coelomic fluid, the weights of the drained animals under sea water, and the density of that water, it was calculated that the fluid had a density about mid-way between that of distilled and sea water.

Samples of the coelomic fluid were collected from three species of mid-water squid (*Verrilliteuthis hyperborea* (Steenstrup), *Galiteuthis armata* Joubin, and *Helicocranchia pfefferi* Massy). These fluids, odourless but of bitter taste, were stored in a deep freeze and further studied on return to Plymouth.

The fluids from the three species were almost identical in composition and properties. Density-bottle measurements gave densities between 1·010 and 1·012, which accounted quantitatively for the buoyancy equilibria of the squid. Freezing point depressions were close to the value for sea water, showing that buoyancy was not achieved by simple exclusion of solutes. Of the common ions only ammonium can give a solution isotonic with sea water but of the density found. Tests indicated the presence of high concentrations of ammonium, and analyses by a method[2] insensitive to amines revealed about 480 mM ammonium. The sodium concentration was only about 80 mM, and chloride accounted for the necessary anion. (Sea water, which has chloride as its principal anion, has only a trace of ammonia but 490 mM sodium.)

The fluid's acidity, *p*H 5·2, was doubtless connected with the retention of ammonia in the coelom, for living tissues are permeable to molecular ammonia but relatively impermeable to the ammonium ion which predominates under acid conditions. The acidity accounted for the absence of ammoniacal smell during collection of the samples while the bitter taste of the fluid matched that of an ammonium chloride solution. We have prepared an artificial solution containing sodium and ammonium chlorides in the concentrations found in the coelomic fluid and shown that its density is close to that of the coelomic fluid.

These mid-water squid resemble the protozoan *Noctiluca*[3] in having a high concentration of ammonium ions which preserve tonicity and yet give buoyancy. In 'design' these squid are strikingly similar to the bathyscaphe, relatively recently devised by Prof. Piccard, in that their useful but dense parts are balanced by a large flotation chamber containing a fluid of lower specific gravity.

We would like to thank our colleagues at the Plymouth Laboratory for advice and help and Captain C. A. Hoodless and the crew of R.V. *Sarsia* for their enthusiastic co-operation.

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Relationships between the Chloride and Iodide Uptake of Wheat Seedlings

THE theory that plants absorb ions by the action of carriers has become general during the past decades. It is an intermediate labile complex, formed by a combination of the carrier and the ion, which traverses the membrane impermeable to free ions. Upon arriving at the inner surface, the complex breaks down and releases the ion carried by it. Epstein *et al.*[1] suggest that different carriers are involved for different groups of ions. A common carrier mechanism is, for example, operative for chloride, bromide and iodide ions[2]. It was demonstrated a few years ago that two separate systems of carriers act in the uptake of differently dissociated phosphate ions[3], while, recently, likewise two separate carriers have been postulated for the absorption of monovalent cations[4]. It has thus become necessary to collect additional data concerning the uptake of monovalent anions.

The results of experiments performed by Sutcliffe[5] with disks of red beetroot point to the possibility that mutual interference between the uptake of different alkali ions is more intricate than used to be supposed. If an ion *A* is a competitive inhibitor of the uptake of another ion *B*, the latter may either inhibit or stimulate the uptake of *A*, according to whether the carrier exhibits a preference for its absorption. Sutcliffe claims the existence of such interaction between sodium and potassium. We are not aware of this kind of correlation between other pairs of ions, probably for the reason that mutual interference between the uptake of different ions has been investigated mostly in one direction only.

Seedlings of winter wheat, variety *F.* 481, were used in our experiments. We sterilized the seeds with hydrogen peroxide and then germinated them in Petri dishes for two days at a temperature of 26° C. The seedlings were transferred to perforated disks and the latter placed upon the surface of a tenfold-diluted Hoagland solution. The plants were then grown for two more days in the nutrient solution at 21° C. After this, the seedlings, with the perforated disks, were transferred to Lundegårdh vessels for the purposes of 24-hr. experiments, which, like the growing of the seedlings, were performed in the dark, in a damp atmosphere.

Combining five chloride- and five iodide-levels (0, 0·5, 5, 25 and 50 m.equiv.) we obtained twenty-five variants. At the termination of the experiment, the roots were twice rinsed with distilled water, after which the roots and the shoots were dried separately. (Seeds were not analysed.) The samples were burnt in oxygen[6], and this was followed by electrometric titration. After having acidified the solution, the released iodine was dissolved in chloroform and measured photometrically. Uptake is given in μ.equiv. in respect of the test plants used in each variant. Figures represent the mean value of results from two replications.

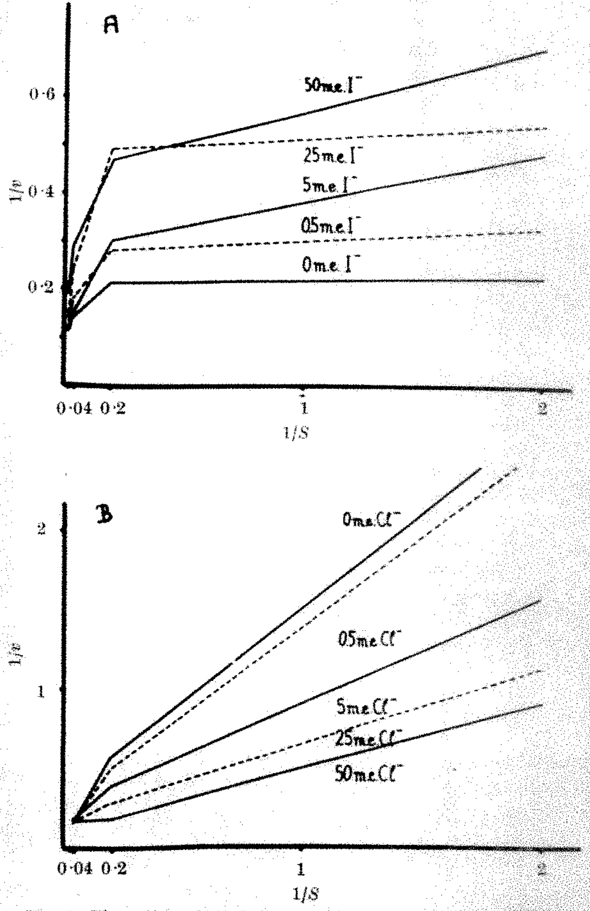

Fig. 1. The action of iodide levels on the accumulation of chloride (*A*), and the action of chloride levels on the accumulation of iodide (*B*) in the roots

As usual, the reciprocal of the rate, at which the roots accumulate chloride and iodide, $1/v$, is plotted against the reciprocal of concentration $1/S$ (Fig. 1, *A* and *B*). Lines so obtained are characteristically curved for both ions: this points, according to the kinetic analysis, to the participation of two carrier

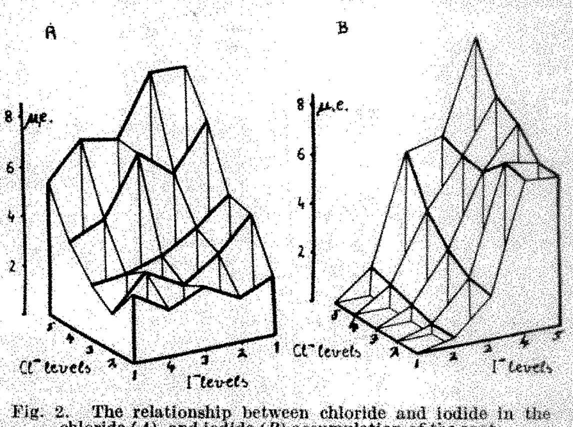

Fig. 2. The relationship between chloride and iodide in the chloride (*A*), and iodide (*B*) accumulation of the roots

systems. On plotting v against v/S we obtain likewise curves which are perfectly similar to those described by Fried and Noggle[4]. (It should be noted that we did not deduct the original chloride content of the roots as we had the impression that, at higher iodide concentrations, it dropped below the initial value.) We regard the deviation of our results from those of earlier authors as a result of experiments over a wider concentration-range.

That chloride and iodide ions exercise different effects on the absorption by the roots is well shown in Fig. 1, and this phenomenon is still more conspicuous from the stereo-diagram (Fig. 2). In order to make it clearer, the respective chloride and iodide levels have been plotted on the two abscissæ equidistantly and not at the points corresponding to the actual concentrations. Increase in iodide concentration inhibits chloride uptake while, surprisingly, increased chloride concentration stimulates iodide accumulation.

Represented by a double reciprocal plot, the accumulation of chloride and iodide in the shoots follows the same course as described in connexion with the roots. The stereodiagram clearly reveals the strong inhibitory effect of iodide on chloride accumulation. In contrast to what has been said concerning roots, the stimulatory influence of chloride on iodide uptake cannot be observed except at low iodide concentrations.

Further details of our results, and data regarding the relationships between chloride–bromide and bromide–iodide, will be published in the *Acta Botanica Hungarica*.

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Fixation of Nitrogen-15 by Excised Nodules of *Coriaria arborea* Lindsay

Bond[1] has recently directed attention to the occurrence of root nodules on species of *Coriaria* growing in New Zealand. We have found nodules on young plants of *C. arborea* but not on *C. sarmentosa*. The other five species of *Coriaria* recognized[2] as occurring in New Zealand have not yet been examined for nodules. *C. japonica*, endemic in Japan, has long been known to be nodulated, and evidence has been produced indicating its capacity for nitrogen fixation[3].

In the experiments reported here, whole plants of *Coriaria arborea* were dug in the field and brought into the laboratory with the root systems tied into plastic bags to guard against excessive loss of water. Nodules and nodule clusters were then excised, brushed free of adhering soil, washed and placed in contact with a nitrogen-free inorganic nutrient solution in a glass container. Each sample consisted of several nodules and nodule clusters with a total fresh weight of 3·4 gm.

The container was evacuated to 0·5 atmosphere and then the pressure was restored to atmospheric by the introduction of nitrogen containing approximately 60 atom per cent nitrogen-15. The gas mixture surrounding the nodules now contained approximately 10 per cent oxygen and 90 per cent nitrogen with 30 atom per cent excess nitrogen-15. The time-intervals between digging the plants and exposing the nodules to nitrogen-15 did not exceed 50 min. The nodules were left in the darkened container for 24 hr. at laboratory temperature of 27 ± 2° C. and then extracted with 3 N hydrochloric acid[4]. The extract of a single sample contained approximately 3·0 mgm. nitrogen. Distillates from Kjeldahl digestions of the extracts were submitted for nitrogen-15 assay to the Division of Nuclear Sciences of the Department of Scientific and Industrial Research.

Acid extracts of three samples of nodules were found to contain 0·89, 0·71 and 0·51 atom per cent excess nitrogen-15, giving clear evidence of the fixation of nitrogen-15.

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Growth-promoting Effect of Ethanol on Oat Seedlings

The effects of carbon dioxide on the growth of etiolated oat seedlings[1]—promotion of the mesocotyl and depression of the coleoptile—have been under investigation for some time[2,3] and the observed behaviour has been attributed to a prolongation of the activity of the nodal meristem[2]. Attempts have recently been made to correlate these growth phenomena with auxin metabolism by supplying indoleacetic acid (10 p.p.m.) to intact oat seedlings via their roots. In these experiments promotion of the mesocotyl was observed when ethanol was used as the solvent for indoleacetic acid but not when the potassium or ammonium salts were used dissolved in water. The effects on growth of 0·2 and 0·3 per cent ethanol were investigated, and they occasioned growth responses which exactly parallelled those induced by carbon dioxide.

The measurements of fifteen replicates per treatment (mm.) recorded in Table 1 were derived from an experiment in which plants were pretreated in darkness with ± carbon dioxide (5 per cent) ± ethanol (0·3 per cent) for 3 days from the time of planting, after which one set was exposed to dim red light (1 foot-candle) for 5 min. while the other set remained in darkness, and these were measured when 7 days old. The duplicate initial measurements (3 days old) thus estimate the lengths of the plant organs at the time of exposure to light, and, since no further treatment with ethanol and carbon dioxide was given, the subsequent growth responses were after-effects.

Table 1. LENGTHS, IN MM., ATTAINED IN THREE DAYS BY OAT SEEDLINGS BEFORE ILLUMINATION. EACH ENTRY IS THE MEAN OF FIFTEEN REPLICATES

Carbon dioxide	+	−	+	−	+	−	+	−
Ethanol	+	+	−	−	+	+	−	−
Mesocotyls	10·3	16·1	21·1	32·7	11·2	15·9	22·1	31·8
Coleoptiles	4·7	7·3	6·8	12·1	4·5	6·8	7·1	10·3
	Lengths of plants (mm.) when seven days old							
	Illuminated				Not illuminated			
Mesocotyls	76·2	57·4	56·7	46·0	123·7	91·6	96·8	58·0
Coleoptiles	48·5	58·6	63·1	66·0	43·8	60·8	61·6	72·8

The growth of both mesocotyls and coleoptiles was depressed by each factor during pretreatment, and the administration of both simultaneously was more depressive than either singly.

Between 3 and 7 days in darkness both treatments induced promotion of the mesocotyl to approximately the same extent (increment 33·6 and 38·8 mm.) while the combined effect (increment 65·7 mm.) was almost equal to the sum of the individual effects. After illumination the untreated mesocotyls (−carbon dioxide, −ethanol) increased in length by 13·3 mm., but the depressive effect of light was almost eliminated by pretreatment with either carbon dioxide or ethanol (compare 56·7 and 57·4 with 58·0 mm.), while the combined effect was promotive (compare 76·2 with 58·0 mm.). These treated plants were nevertheless very sensitive to light, which depressed mesocotyl growth from 123·7 mm. to 76·2 mm., a proportionately greater decrease than that shown by the controls 58·0 to 46·0 mm.); similarly with each factor separately.

In connexion with the suggestion that carbon dioxide prolongs the meristematic phase, it may now be said that ethanol does likewise, and it is therefore of great interest that it has recently been shown that ethanol stimulates cell division in algæ[4,5].

Further data and a discussion of the significance of these findings will be published shortly. Meanwhile the matter is under investigation.

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Host Specificity in *Xanthomonas*

Burkholder and Starr[1] stated that "unequivocal identification by laboratory procedures of all *Xanthomonas* species is as yet an impossibility", and there has been no change in this position in recent years[2,3]. The diagnosis of *Xanthomonas* species therefore depends on the host specificity of the organisms. Wernham[4] inoculated cultures of fourteen pathogenic *Xanthomonas* into twelve different hosts and found them to be "remarkably specific in their host reactions". He also stated that "there is no possibility of error in using the host as a species determiner". However, since the host ranges of most of the organisms have never been completely determined the classification of the genus is not securely established.

Table 1. CULTURES EXAMINED

Species	Source*	Normal host
X. alfalfae	ITCC (*B* 37)	*Medicago sativa* L.
X. begoniae	NCPPB (241)	*Begonia boliviensis* D.C.
X. beticola	ITCC (*B* 45)	*Beta vulgaris* L.
X. betlicola	M. K. Patel (11), India, via M.P. Starr (*XB* 104), U.S.A.	*Piper betel* L.
X. campestris	E. Billing (*P* 25), Wye, U.K.	*Brassica* spp.
X. campestris var. *armoraciae*	NCPPB (347)	*Amoracia rusticana* Gaertn., Mey and Scherb.
X. citri	D. W. Dye (*R* 3), N.Z.	*Citrus* spp.
X. geranii	ATCC (11056), via M. P. Starr (*XG* 1) U.S.A.	*Pelargonium* spp.
X. hyacinthi	A. F. G. Slootweg (18-*X*), Holland	*Hyacinthus orientalis* L.
X. juglandis	D. W. Dye (*S* 14), N.Z.	*Juglans regia* L.
X. malvacearum	NCPPB (293)	*Gossypium* spp.
X. nigromaculans f. sp. *zinniae*	NCPPB (189)	*Zinnia* spp.
X. papavericola	W. H. Burkholder via M. P. Starr (*XP* 17), U.S.A.	*Papaver rhoeas* L.
X. pelargonii	E. Hellmers (69), Denmark	*Pelargonium* spp.
X. poinsettiaecola	ITCC (*B* 46)	*Euphorbia pulcherima* Willd.
X. pruni	D. W. Dye (*T* 8), N.Z.	*Prunus* spp.
X. punicae	NCPPB (466)	*Punica granatum* L.
X. ricinicola	ITCC (*B* 48)	*Ricinus communis* L.
X. translucens	W. A. F. Hagborg (3068), Canada	*Triticum aestivum* L.
X. vesicatoria	D. W. Dye (*X* 3), N.Z.	*Lycopersicum esculentum* Mill.

* ITCC, Indian Type Culture Collection, New Delhi, India; NCPPB, National Collection of Plant Pathogenic Bacteria, Harpenden, Britain; ATCC, American Type Culture Collection, United States.

Recently, some cross-inoculation tests were carried out as follows: bean plants (*Phaseolus vulgaris* L.) variety Canadian Wonder, were grown from seed in sterilized soil in sterilized 4-in. pots. When the first trifoliate leaves were half developed the plants were placed for 24 hr. in a cabinet into which a fine mist of sterile water was automatically sprayed for 45 sec. every 30 min. Leaflets were then punctured in the midrib with a sterile needle. A small quantity of each of the *Xanthomonas* cultures listed in Table 1 in yeast-extract nutrient broth (yeast extract, 'Difco', 5 gm.; peptone, 5 gm.; 'Lab-lemco', 5 gm.; water, 1 l., *p*H 6·8) which had been incubated at 27° C. for 24 hr. was then placed on the leaflets by pipette. Inoculum was also placed on the unfolding second trifoliate leaves, which were not punctured. Each plant was immediately covered with a transparent plastic bag which was tied tightly around the pot in order to provide a humid atmosphere about the plant. After 3–5 days the plants were examined and isolations were made from lesions. If no lesions were apparent isolations were made from the points of needle puncture. Xanthomonads were re-isolated without difficulty in all instances. Three isolates, each from a different lesion or puncture, were incubated for 24 hr. in yeast-extract nutrient broth. The three cultures were then mixed and inoculated into fresh bean plants as before. The object of combining the three isolates was to reduce the chances of using non-pathogenic mutants. The process of inoculation, isolation and re-inoculation was carried out four times. On the last occasion lesions were allowed to develop for seven days before the result was recorded. A progressive disease was produced by the cultures listed in Table 1. Dark green to black, angular lesions 2–4 mm. in diameter appeared at the sites of puncture, and the veins showed browning and collapse for 3–5 mm. Some lesions as they aged became light brown. Yellow chlorotic areas developed around many lesions. On parts which had not been pricked, dark green water-soaked angular spots developed, particularly on the younger leaves (Fig. 1). When lesions coalesced the effects were frequently severe and caused defoliation. Some lesions extruded a slimy mass of bacteria which were found to be xanthomonads.

The lesions which developed without the tissues having been damaged were regarded as good reproductions of natural infection and were considered as

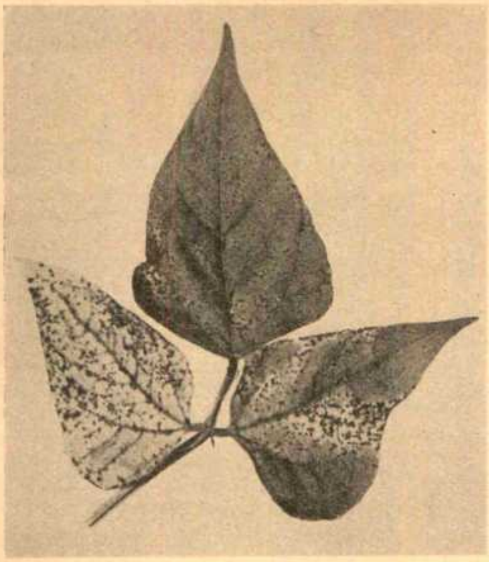

Fig. 1. The typical effects produced on bean leaves by the various species of *Xanthomonas*

proof that the bacteria had become adapted to their new host. This type of infection could not invariably be distinguished from that caused by *X. phaseoli*, though this organism frequently caused a more extensive pale green necrosis and wilting. It seems possible that the organisms originally isolated from other hosts would, with further adaptation to the bean, produce symptoms identical with those due to *X. phaseoli*. Single-colony isolates were in each case shown to be indistinguishable in cultural and physiological properties from their parent culture. The ability of *X. phaseoli* var. *fuscans*, *X. punicae* and *X. ricinicola* to produce a brown stain in media was a convenient label for these organisms, and provided evidence that unintentional cross-infections did not occur.

There seems to be no reason to suppose that the inoculations were carried out under unnatural conditions. Actively growing bacteria were merely applied in sufficient numbers to susceptible parts of bean plants under the conditions of humidity and temperature which commonly promote infection in temperate and sub-tropical climates. The findings suggest the possibility that a similar result might be obtained with other hosts and that the host specificity of the xanthomonads may not be a stable character. The fact that cultures originally isolated from twenty different hosts can infect bean plants is, at the least, evidence of a close relationship among these organisms.

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Preparation of Virus Antisera from Strawberry

STRAWBERRY contains tanning agents in such quantity that water extracts of strawberry leaves contain no appreciable amounts of protein and will, moreover, precipitate serum proteins, thus being unsuitable for serological work with viruses that infect the plant[1]. This is also true of other rosaceous plants, and thus most workers have tried to find other hosts for viruses affecting members of the Rosaceae before attempting the preparation of specific antisera.

It now seems that this step is not necessary in preparing antisera to some viruses from rosaceous plants, since by the use of recent techniques for the removal of tanning agents from leaves during maceration[2], satisfactory antisera have been prepared to two viruses from strawberry leaves, namely, raspberry ringspot virus from the variety Huxley, and raspberry yellow dwarf virus from the variety Cambridge Favourite. Both these are soil-borne viruses which are widespread and of local importance in strawberry in Scotland, and they can be transmitted mechanically from strawberry to a number of herbaceous host plants[3].

In each case, leaf extracts were prepared by the following method, found to give a high yield of virus in preliminary investigations in which extracts prepared in various ways from Huxley strawberry infected with raspberry ringspot virus were assayed on the leaves of *Chenopodium amaranticolor* (Coste and Reyn.) plants.

Mature leaves harvested from infected plants in the field were shredded and then ground in a mortar with an equal weight of 5 per cent nicotine base and sufficient coarse carborundum powder to ensure thorough maceration. The liquid expressed by squeezing the macerate through muslin was then clarified by slow-speed centrifugation and dialysed against running tap-water overnight to remove excess nicotine. After further dialysis against 0·85 per cent saline, the preparations were stored frozen. Antisera were prepared by the intravenous injection to rabbits of 2 ml. aliquots of these preparations at twice-weekly intervals over a period of three weeks. Both antisera were of moderately high titre—about 1/256—measured by precipitin tests against clarified sap from infected leaves of *Petunia hybrida* Vilm. This titre compares well with those obtained using infected *P. hybrida* or *Nicotiana tabacum* L. as the source of virus[4]. It is of interest that the viruses in preparations made in this way did not give a visible precipitate when incubated with their homologous antisera, but did so only if concentrated after precipitation with acetone.

It is thought that this method, refined by the use of ultracentrifugation or freeze-drying, may be of value in preparing antisera to other viruses directly from rosaceous hosts. A fuller account of the development of the method is to be published elsewhere.

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Sol-Gel Transitions in the Living Cells of Conifers and their Relation to Resistance to Cold

THE cause of cold hardiness changes in over-wintering phanerophytes has long been sought in the characteristics of the cytoplasm. Yet there are sharp disagreements on whether the cytoplasm becomes more viscous or less viscous in winter. At the same time the characteristics of the vacuole have not been so carefully studied by cytologists. Both Iljin and Rouschal[1], however, believed that the extraordinary drought resistance of certain ferns was related to the ability of the vacuoles to gelate.

Such a gelation could occur in the leaves and bark of over-wintering plants like pines and thus stabilize the cytoplasm against distortion during the dehydration accompanying ice formation. Gelation of the cell contents of trees has been mentioned in the literature; but observations are not supported by clear evidence. Some have felt that the gelation is 'protoplasmic', at least in cambial cells of trees[2]; yet others have left it open to question as to the exact part of the cell gelating[3,4]. In the meantime, others have concluded that the cytoplasm becomes more fluid in winter than in summer[5], so that gelation or even increased viscosity (an idea supported by numerous workers) would seem unlikely. Observations of protoplasmic streaming in pine cambial cells[6] would seem to throw light on the matter; but protoplasmic streaming is probably not a good measure of viscosity, and streaming is commonly lacking in many of the mature living conifer cells in any season.

In our work it became clear that in the endodermis and transfusion parenchyma cells of the leaves of *Pinus ponderosa*, *P. strobus* and *P. monticola*, the vacuoles pass from a sol to a gel condition in the late autumn, that is, from a liquid of about 3 on the viscosity scale of Seifriz[7] to one of about 8. This was indicated by a marked slowing down and finally a cessation of Brownian movement of vacuolar particles. It is believed that this phenomenon may contribute to, although not explain, the autumn hardiness increases.

Another curious thing observed in the course of seasonal microscopic studies of *P. strobus* bark cells was that the starch grains sink down in the ray cells due to gravity alone in January and remain thus into March. At the same time nuclei in the adjacent vertical phloem parenchyma were often found to be acropetal. In summer it was necessary to centrifuge bark cells at 1,500 r.p.m. in order to throw down the starch grains. This suggests a decreased cytoplasmic viscosity in winter, to use the terminology of Heilbrunn[8], and might even be considered a gel-to-sol transition.

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Genetical Interference in *Drosophila* spp.

IN chromosomes II and III of *D. melanogaster* Owen[1] found good agreement with the interference function $4u\exp(-2u)$ which is distributed as $\frac{1}{4}\chi^2_4$. In the X-chromosome the position was more doubtful, possibly due to misclassification, which tends to inflate the rare double recombinant classes in multi-point linkage tests, hence altering the estimates of the intensity of interference.

It was therefore thought profitable to examine back-cross linkage data involving three or more genes in some of the other species of *Drosophila*. The method of analysis has been sketched by Parsons[2,3]. This involves plotting the Kosambi coefficient[4], K, against the mean of the map distances for each three point test. On the $\frac{1}{4}\chi^2_4$ metric, $K = 1$ at the metrical mid-arm of long chromosome arms, which corresponds to a point one-third of the map distance from the centromere. Closer to the centromere $K > 1$, and farther from it $K < 1$. Thus graphs of K against the mean of the map distance may be compared with an expected graph, and if the centromere can be located accurately the observed metrical mid-arm may be compared with the expected, as has been done for maize[2,3].

Data for the six species *D. simulans*, *D. virilis*, *D. sub-obscura*, *D. prosaltans*, *D. pseudo-obscura* races *A* and *B* and *D. willistoni* were examined. In many cases the K values were very variable. Some of the variability was removed by eliminating genes prone to misclassification, but some remained, and may possibly be due to gonial crossing-over[5]. In the data for *D. prosaltans*[6], for example, cross-over values and hence K values varied enormously. In the X-chromosome the K values increased towards the centromere, showing that interference is less intense near the centromere. In chromosomes II and III, the situation was not obvious, possibly due to a lack of data.

On the whole, however, with the exception of the X-chromosome of *D. virilis*, the K values were less scattered, and a definite graph of K increasing towards the centromere could be drawn for the X-chromosomes of *D. simulans*, *D. pseudo-obscura* race *B* and *D. willistoni* (Brazilian and Cuban strains), chromosome II of *D. simulans* and *D. pseudo-obscura* race *A*, and chromosome III of *D. pseudo-obscura* race *A*. In the X-chromosomes of *D. sub-obscura* and *D. pseudo-obscura* race *A*, and chromosome III of *D. simulans* there was no apparent trend, but the points did not disagree with expectation. For the remainder of the chromosomes the data were inadequate.

Thus the well-established phenomenon of interference becoming more intense with distance from the centromere is not contradicted. However, on the whole, the data are very much more variable than in maize[2,3], and testing them against a specific metric does not appear to be possible. It can be said that it is unlikely that interference is much more severe than that predicted by the $\frac{1}{4}\chi^2_4$ metric, for on the $\frac{1}{6}\chi^2_6$ metric developed by Payne[7], K is expected to be $<0{\cdot}3$ at 20 to 30 centimorgans from the centromere. Most of the observed values in this region were much closer to unity, which represents the degree of interference predicted by the $\frac{1}{4}\chi^2_4$ metric.

However, it cannot be expected that all the data will fit one metric, since a metric, like recombination, varies according to genetic and environmental conditions. To specify the situation fully, it is probable that a family of interference functions of similar form will be needed. Behind every interference function there must be some basic assumption.

which, on observations and theory to date, must be[1,4]: (1) no interference across the centromere; (2) independent distribution of intercept-lengths when measured on an interference metric; (3) no repressive effect of the terminus on chiasma formation. Presumably, therefore, each metric will be of similar form. A small adjustment will allow for changes of the environment or genetic background, and in some organisms, such as the house mouse[8], a different metric will be needed for each sex.

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Resistance to Pyrethrins and to Pyrethrins - Piperonyl Butoxide in a Wild Strain of *Musca domestica* L. in Sweden

Although synergized pyrethrins have been used for fly control for many years, there is no published record of *Musca domestica* L. becoming resistant to this insecticide in the field.

During 1947–56, the fly population of a farm (Wasa) near Stockholm had developed high resistance to many of the chlorinated hydrocarbon insecticides and some resistance to parathion. Commercial insecticides containing pyrethrins and the synergist piperonyl butoxide were used in the latter part of 1956 and early 1957, but by October of that year it was reported that they no longer killed the flies.

Larvæ and pupæ of *Musca domestica* L. were collected at this farm and bred under standard conditions at the Statens Skadedyrlaboratorium, Springforbi, Denmark, and the Cooper Technical Bureau, Berkhamsted, England.

At Springforbi the resistance of the first and later generations was measured by topical application to the dorsal thorax of female flies of a mixture of pyrethrins plus piperonyl butoxide (1 : 10) dissolved in acetone. The mortality was observed after 24 hr. and the median lethal dose (*LD*50) per 20 mgm. of fly estimated from plotted regression lines. Comparative tests were carried out with laboratory strains representing various resistance patterns, which, as far as we know, have not been exposed to selective treatment with pyrethrins.

Table 2. Resistance to Pyrethrins and to Pyrethrins plus Piperonyl Butoxide of a Wild Strain of *Musca domestica* L. collected from a Farm in Sweden

Spray tests with oil solutions. (Means of six replicate tests)

Strain of *Musca domestica* L.	Percentage concentration (w/v) of insecticide Pyrethrins	Piperonyl butoxide	Percentage mortality in 24 hr.	*LD*50 (percentage concentration)	Resistance	*KD*50c (min.)
Laboratory	0·10 0·25 0·40 0·50	— — — —	14 45 54 61	0·32	1	2·60 1·75 1·30 1·15
Swedish (Wasa)	3·25 4·00 5·00 7·00 10·00	— — — — —	35 51 58 82 87	4·00	12·5	>10 >10 >10 >10 >10
Laboratory	0·03 0·04 0·05 0·075	0·24 0·32 0·40 0·60	42 48 65 91	0·041/0·328	1	4·20 3·30 3·10 2·30
Swedish (Wasa)	0·30 0·50 0·625 0·75	2·40 4·00 5·00 6·00	21 59 83 93	0·44/3·5	10·7	>10 >10 >10 >10

The results (Table 1) showed that the *LD*50 of the Wasa flies (3·3 µgm.) was 11–14 times that of the susceptible strains Enø and 7. After seven generations in the laboratory without exposure to insecticides, the resistance of the Wasa strain decreased significantly but was still remarkably high (2·1 µgm.).

Moreover, the Wasa strain showed high resistance to chlorinated hydrocarbons, and the *LD*50 obtained with the organo-phosphorus compounds, 'Diazinon' (1·2 µgm.; 30 times normal) and parathion (0·13 µgm.; six times normal) was comparable to the highest measured in Danish field-populations[1].

The laboratory strains which were resistant to chlorinated hydrocarbons or organo-phosphorus compounds are also more tolerant to synergized pyrethrins than normal (2–4 times). This indicates that the resistance to synergized pyrethrins is partly due to non-specific factors ('vigour tolerance') and partly to specific defence mechanisms against synergized pyrethrins.

At the Cooper Technical Bureau the resistance of the F_3 generation to pyrethrins, and to pyrethrins plus piperonyl butoxide in a ratio of 1 : 8, was compared with that of the normal laboratory stock. Flies were sprayed with solutions of these insecticides in odourless kerosene. A modification of the direct-spray technique evolved by Kearns and March[2] was used.

Table 1. Tolerance to Pyrethrins and Piperonyl Butoxide of a Swedish Strain (Wasa) of *Musca domestica* L. compared with Danish Strains

Topical application of acetone solutions

Strains	Year of collection	Resistance to: DDT	Lindane	Chlordane	Organo-phosphorus compounds	Tolerance to pyrethrins/piperonyl butoxide, 1 : 10 — *LD*50 µgm. per female fly (20 mgm.) with 95 per cent confidence limits	Slope
Swedish							
Wasa F_1	1957	+++	++	+++	++	3·3 (2·9–3·7)	6·3
Wasa F_8	1957					2·1 (1·8–2·4)	6·3
Danish							
No. 7	1948	(+)	–	–	–	0·24 (0·19–0·30)	4·0
Enø	1955	–	–	–	–	0·31 (0·27–0·37)	8·8
No. 17*e*	1950	++	++	++	–	0·55 (0·45–0·68)	5·1
No. 150*a*	1955	+			+	0·52 (0·43–0·63)	4·3
No. 203*a*	1957	+++	++	++	++	0·98 (0·76–1·29)	2·4

Symbols for resistance: +++, high; ++, moderate; +, slight; –, none.

The concentration of insecticide required to give 50 per cent mortality (*LD*50) was calculated for each insecticide with each strain of flies from log probit regression lines. Knock-down was recorded in addition to the percentage mortality and the *KD*50c (time taken to knock down 50 per cent of flies) obtained with each solution was calculated.

The results (Table 2) showed that the Wasa strain was 12·5 times more resistant to pyrethrins, and 10·7 times more resistant to pyrethrins plus piperonyl butoxide, than the normal laboratory strain. Resistance to the knock-down effect of these insecticides was also shown.

It may be of interest to other workers to note that preliminary tests carried out at the Cooper Technical Bureau have indicated a resistance to 'Allethrin' and to 'Allethrin' with piperonyl butoxide. Using a measured drop technique, resistance to 'Allethrin' was about 150 times, and to 'Allethrin' with piperonyl butoxide about 45 times, that of the normal laboratory strain.

The conditions for development of this reported resistance seem to have been especially favourable in Sweden during the past few years. As the chlorinated hydrocarbons and organo-phosphorus compounds failed to control the flies, dusts with a low content of synergized pyrethrins (at Wasa 0·075 per cent pyrethrins plus 0·6 per cent piperonyl butoxide) were used widely throughout the fly seasons, and flies were exposed to a wide range of dosages as the pyrethrins deteriorated. In addition, aerosols containing concentrations of synergized pyrethrins below that normally required for adequate fly control were used. Increasing difficulty in killing flies with pyrethrum insecticides, both dusts and aerosols, was reported from several places in Sweden in 1957, but the resistance was not measured by laboratory tests.

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Changes in the Tiller Population of Grass Swards

ONE of the characteristic attributes of perennial herbage grasses is their ability to produce tillers in large numbers. Since each tiller, in passing through its life-cycle, lives for a variable but limited amount of time, the growth of the plant will reflect the sum of the individual life-histories of its tillers. There is continuous change throughout the year as new tillers appear and others decay, so that counts of tillers at any one time represent no more than a census of an ever-changing population.

Discernible seasonal trends in the number of tillers present in the sward have been shown in several species. The indications are that density of tillers increases after the summer, possibly continuing into the winter, but that after the onset of active growth in the spring a marked decline occurs[1,2] which may be prolonged and severe if growth is allowed to proceed uninterruptedly[3]. A cut at the hay stage when ears have emerged will remove large numbers of tillers which may not be replaced immediately, thus leading to a further decrease in the tiller population.

Table 1. NUMBER OF LIVING TILLERS PRESENT PER 1 SQ. F

1958	Hay and aftermath		Frequent cutting	
	Meadow fescue	Timothy	Meadow fescue	Timothy
March	606	526	823	[illegible]
April	578	542	822	[illegible]
May	522	361	718	675
June	504	264	484	504
July	524	319	516	[illegible]
August	439	314	531	614

Recent experiments, in which the performance of individual tillers of plants growing in large containers but otherwise under field conditions has been followed, suggest that these fluctuations in number are accompanied by considerable changes in the composition of the population in respect of age, as tillers come and go. These changes do not appear to be confined to swards which are cut for hay after flowering has occurred, as would have been expected, but also occur in frequently defoliated swards in which inflorescences are not allowed to appear.

Table 1 shows the results of a census of the number of tillers starting in March 1958 and repeated at intervals of 4 weeks. The swards under investigation were either *S*.215 meadow fescue or *S*.48 timothy sown without clover in 1956 and subjected to one of two managements: cutting for hay and aftermath, or frequent cutting (every 4 weeks beginning early in April). Both grasses maintained a greater population of tillers in response to frequent cutting than under the hay and aftermath system. Within each treatment, tiller numbers tended to be high early in the year but they declined after the middle of April, whether the swards had been cut by that time or left to grow until ears had emerged (late May in meadow fescue, late June in timothy).

These seasonal variations in number were accompanied by marked changes in the composition of the tiller population, as shown by the number of new and dead tillers at each date of observation (Table 2). For the purpose of this study no distinction was drawn between tillers which had died from natural and unspecified causes, and those that had been killed by having their apical meristem removed through cutting.

In both meadow fescue and timothy, cutting for hay after ears had emerged led to heavy casualties among tillers, but replacement appeared to be rapid and roughly proportional to the losses sustained. As

Table 2. NUMBER OF NEW AND DEAD TILLERS PER 1 SQ. FT.

1958	Meadow fescue		Timothy	
	New	Dead	New	Dead
	Hay and aftermath			
March	34	26	42	22
April	29	57	27	11
May	35	91	2	183
June	226	269	138	229
July	70	50	146	96
August	39	124	77	82
	Frequent cutting			
March	74	41	23	22
April	21	42	37	37
May	52	156	16	116
June	98	332	234	404
July	40	9	236	167
August	57	42	122	58

a result, a large part of the tiller population in August was of fairly recent origin. Similar changes also occurred under a system of repeated defoliations, although ears were never allowed to appear. Thus in timothy, about 690 tillers per sq. ft. died or were decapitated between May and July, while some 490 new tillers appeared. Heavy losses were also recorded in meadow fescue; replacement was less rapid, but the results obtained in the previous year suggested that in this grass tillering continues actively into the winter. Although no marked fluctuations in tiller numbers could be detected, there had nevertheless been considerable change in the composition of the tiller population, with most of the older tillers disappearing and new ones taking their place.

A large part of these internal changes was no doubt attributable to the fact that many tillers had moved from the vegetative to the reproductive condition at a time determined by the day-length requirements of the plant. After this transition had gone some way, internode elongation will have occurred, so that in course of time differentiated shoot apices were lifted sufficiently high above the ground to become vulnerable to cutting. This would account for the high casualties sustained by both grasses around the time when they usually flower if allowed to produce ears.

In consequence of this striking loss and replacement of tillers, the composition of swards in August was very different from that earlier in the year. It may be suggested that these differences play a part in the seasonal pattern of dry-matter production in the grasses. Tillers which appear in the autumn or winter are usually well established by the time environmental conditions favourable for growth arise in the spring. There then follows a period of intense accumulation of dry-matter, characterized by exceptionally high growth-rates[3] and continuing to around the time when flowering occurs. Whether inflorescences are allowed to emerge or not, a cut taken after internode elongation has gone some way will result in the removal of a large part of the older tillers and their replacement by new shoots. Since very young tillers appear to go through a period of establishment[4], the plant may not be able to continue production of dry-matter at the same rate as in the pre-flowering period, before the tiller complement was changed. This may be more noticeable under difficult climatic conditions and in strains which naturally flower late and thus produce tillers when some environmental factors are no longer optimal. It is thus possible that the decline in the productivity of grasses commonly experienced in the summer is connected with the change in the tiller population, even though no indication of this can be obtained from tiller counts. The suggestion of breeding non-flowering strains to overcome this problem has already been put forward[5], although there may possibly be other means of ensuring that a greater proportion of the tillers present early in spring survive through the summer and contribute to the total dry-matter production of the plant.

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Importance of Taxonomy in Biological Investigations

Often in biological investigations no attempt is made to define with precision the species upon which the investigation was carried out. Terms without specific connotation, such as 'frog' or 'monkey', are used. This lack of precision may mean that data are lacking which may afterwards prove to be of significance in relation to the purpose of the paper.

Another reason why precision in identification of species is desirable is that there is probably much to be gained from a greater integration of knowledge obtained by investigation of living forms with our knowledge of taxonomy, gleaned in large measure from the fossil record of extinct forms. This will only be possible if all types of biological investigators pay attention to the taxonomical classification of the subjects of their study. Such a correlation of knowledge should reflect to the benefit not only of taxonomy but also of biological science in general. So far as comparative anatomy is concerned, a closer consideration of taxonomy and modern concepts of the relation of groups in the evolutionary process should prevent the hasty drawing of false homologies between structures which are only superficially similar.

The following example indicates the mutual benefit that may derive to descriptive anatomy and taxonomy by attempting correlation between them. Among selachian fishes (that is, members of the sub-class Selachii of the class Elasmobranchii[1]) fusion of the two lateral telencephalic lobes of the forebrain occurs, except in *Scymnorhinus*, in which the lateral telencephalic lobes remain unfused. The primary site of attachment of the nervus terminalis is on each side lateral to the lamina terminalis, but this is only clearly seen in the mature brain in *Scymnorhinus*. In other forms the proximal part of the nerve is incorporated in the brain by the fusing telencephalic lobes, the nerve being carried either dorsally or ventrally in this process, so that its definitive site of superficial attachment is either dorsal or ventral[2]. The nervus terminalis in selachians[3] is thus attached in some forms dorsally to the forebrain and in others ventrally. If the various forms are viewed merely as a number of selachians, this detail of descriptive anatomy, concerning as it does a minute nerve of uncertain function, can scarcely seem to be of much interest, especially when it is remembered that the definitive site of attachment of this minute nerve is secondary, being dictated probably by largely mechanical factors during fusion of the telencephalic lobes. However, if the forms in which the site of attachment of the nervus terminalis has been recorded are reviewed from a taxonomical point of view, it is found that the attachment is dorsal in the skates and rays (sub-order Hypotremata, order Euselachii); and, among the sharks of the order Euselachii, which are classified as the sub-order Pleurotremata, it is dorsal in the superfamily Squaloidea (except in *Scymnorhinus*, see above, in which it is rostral). Among euselachian sharks, the attachment is ventral in the superfamily Scylloidea, and a ventral attachment is found in the protoselachian Port Jackson shark (*Heterodontus*). These results all correlate well with current taxonomical classification. The only inconsistency appears in the superfamily Notidanoidea of euselachian sharks, since in *Hexanchus* and *Heptranchias* the attachment is dorsal[4], whereas in *Chlamydoselachus* it is ventral[5]. The site of superficial attachment of the nervus terminalis may not be of particular taxonomical significance; but it serves to illustrate how accumulated observations might be used to corroborate or to modify taxonomical classification, and how even apparently trivial descriptive details may be seen to have meaning when viewed in the light of taxonomy.

A suggestion for more attention by biological investigators to taxonomy must, unfortunately, be accompanied by a plea for the devotion of more precision and care to the use of correct generic[6] and specific[7] names.

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Information Gain in Tasks involving Different Stimulus-Response Relationships

IN an attempt to clarify issues raised by changes associated with age in the ability of human subjects to perform perceptual-motor tasks, the rates of information transmission of younger and older subjects in performing discrete, choice reaction time tasks involving two different stimulus-response relationships were calculated. The tasks involved moving a stylus as quickly as possible from a central point to one of a number of targets arranged in a semi-circle in response to the appearance of one of a number of signal lights arranged in a similar semi-circle. The first (direct) stimulus-response relationship required subjects to aim at targets corresponding directly in position to signals which appeared. In the second, indirect version of the task, the correct target was the 'mirror image' of that directly indicated by the signal.

It was found that: (1) in all cases, the mean reaction time of subjects was proportional to the amount of information conveyed by the signal; (2) rate of information transmission was lower in both younger and older subjects when the stimulus-response relationship was indirect; (3) in both stimulus-response relationships, the rate of information transmission of older subjects was lower than that of younger subjects. The first of these findings is in line with those of Hick[1], Hyman[2] and others, and the second confirms work by Crossman[3] and others. In these previous studies, however, age was not treated as an experimental variable. The third finding supports a hypothesis of Welford[4] in explanation of age changes in perceptual-motor performance, that the ability to process information centrally deteriorates with age.

The calculated rates of information transmission were derived from the a constants in the functions which were found to fit the mean reaction time data in all cases. These functions all took the general form:

$$R.T. = a \log_2 \frac{1}{p} + b \qquad \text{(I)}$$

where $R.T.$ is the mean reaction time (sec.) to signals the probability of occurrence of which is p. Calculated rates of information transmission were given by the formula:

$$R = \frac{1}{a} \qquad \text{(II)}$$

where R is mean rate of information transmission (bits/sec.).

The specific forms these regressions took were as follows:

Direct S–R relationship	Younger Ss	$R.T. = 0{\cdot}073 \log_2 \frac{1}{p} + 0{\cdot}288$	(III)
	Older Ss	$R.T. = 0{\cdot}094 \log_2 \frac{1}{p} + 0{\cdot}307$	(IV)
Indirect S–R relationship	Younger Ss	$R.T. = 0{\cdot}127 \log_2 \frac{1}{p} + 0{\cdot}296$	(V)
	Older Ss	$R.T. = 0{\cdot}171 \log_2 \frac{1}{p} + 0{\cdot}301$	(VI)

These results lend themselves to interpretation in an interesting manner. The calculation of rates of information transmission on the basis of the a constants of equations (III) to (VI) suggests that in the indirect version of the task lower rates applied than in the direct version. This implies that the information-processing capacity of the human operator varies from task to task, which, on purely *a priori* grounds, is a somewhat unsatisfactory view. This difficulty may be avoided if it is recognized that equations (V) and (VI) may be re-written in such a manner as to retain the values of the a constants present in equations (III) and (IV), respectively. Equation (V), re-written in this manner, would be:

$$R.T. = 0{\cdot}073 \left\{\frac{0{\cdot}127}{0{\cdot}073}\left(\log_2 \frac{1}{p}\right)\right\} + 0{\cdot}296 \qquad \text{(VII)}$$

and equation (VI), re-written, would be:

$$R.T. = 0{\cdot}094 \left\{\frac{0{\cdot}171}{0{\cdot}094}\left(\log_2 \frac{1}{p}\right)\right\} + 0{\cdot}301 \qquad \text{(VIII)}$$

The implication of these re-written equations is that it is not the rate of information transmission which varies from task to task but the amount of information conveyed by signals. In the indirect version of the task, this is increased by the factor by which the expression $\log_2 1/p$ is multiplied. Further, the approximate equality of these factors in equations (VII) and (VIII), 1·74 and 1·80, respectively, suggests that to both younger and older subjects the amount of information conveyed by signals is increased to the same extent.

While involving a modification of the conventional use of information theory in the interpretation of psychological data, the interpretation proposed above appears to represent a useful descriptive foundation upon which the interpretation of data obtained under different conditions of stimulus-response coding may be based. Full details of the experiment and a fuller discussion of the interpretation proposed here will appear elsewhere.

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After-Effect of Movement produced by a Rotating Spiral

Following visual stimulation by a rotating spiral, a negative after-effect of movement is observed. A preliminary report on what variables are relevant has been made by Holland[1]. Eysenck, Holland and Trouton[2] have since claimed that individual differences in length of after-effect conform to predictions from Eysenck's theory. In view of these claims and of the fact that others[3,4] are using this phenomenon in a clinical diagnostic context, it is perhaps important to offer this progress report of further experiments on the extent of normal variation and the factors influencing it.

The number of subjects participating in these experiments was eighty. The spiral was of the same pattern as that used by Eysenck, Holland and Trouton[2]. The principal findings may be summarized as follows:

The variables influencing the duration of the after-effect (*other than individual differences*).

(1) Duration of after-effect is very resistant to changes in illumination over a wide range (approximately 120–20 ft. candles on the surface of the spiral with the subject seated about 5 ft. away) ($N = 30$). Between 27 and 0·4 ft. candles there is a slight drop in mean duration from 10 sec. to 8 sec. ($P > 0{\cdot}05$), but it is substantially unaltered until the spiral is so dim that fusion occurs during rotation, and it is then destroyed ($N = 10$).

(2) Continuous trials cause a decrement in the duration of after-effect. There is a difference between the same condition repeated at the beginning and end of a series of thirteen intervening measurements ($P > 0{\cdot}01$). The same condition, repeated at random among the thirteen, had a mean value midway between the two extremes ($N = 23$).

These findings confirm and extend previous work[1,2], whereas the following observations are discrepant.

(3) Length of stimulation results in increase in the duration of effect over the whole range tried (5 sec.–10 min.). Subjects with persistent after-effects tend to show greater proportional as well as actual gain; for example, between $2\frac{1}{2}$ and 5, and 5 and 10 min. stimulation there is a gain of more than $\frac{1}{2}$, compared with 1/3 and 1/5 respectively in those with very short after-effects ($N = 45$).

(4) The after-effect is shorter using a spiral 3 in. in diameter than one 6 in. in diameter ($P > 0{\cdot}05$, $N = 18$). It is also shorter than when using a disk 12 in. in diameter but not significantly so ($N = 21$).

(5) Of twenty-five subjects only nine were able to view the spiral monocularly and observe the after-effect with the unstimulated eye. Five did so in one direction only, and the other eleven did not find any transfer of the effect. Duration of after-effect tends to be less, but not in all subjects.

(6) Twenty-three out of the twenty-five subjects were able to observe the after-effect on a relatively unstructured surface—a black card. Duration of after-effect differs for individuals from that under the usual conditions of observation, but there is no overall diminution.

Further experiments showed:

(7) That the wave-length of light in which the spiral is viewed has no effect ($N = 11$).

(8) There is no difference produced by contracting and expanding spirals ($N = 20$).

(9) Rotation at 16 r.p.m. produces a significant decrease compared with 45 and 78 r.p.m., between which there is no difference ($P > 0{\cdot}001$, $N = 22$).

(10) Fixation of a point on the periphery of a spiral 12 in. in diameter produces marked decrement compared with fixation of the centre ($P > 0{\cdot}001$) and similarly for fixation of a point 10 in. away from the centre of a spiral 3 in. in diameter ($P > 0{\cdot}01$, $N = 22$).

(11) Monocular viewing slightly decreases the after-effect. Values for each eye separately are lower than for both together ($P > 0{\cdot}1$, $N = 18$).

(12) Striking subjective colours are reported by some subjects, especially with prolonged stimulation, and there is a considerable degree of consistency in the quality and location of the colours seen under particular conditions.

The effect of individual differences. Contrary to previous assertions[2], no significant differences at any of eight different periods of stimulation were found between the 12 most extroverted and 12 most introverted subjects, selected by their extroversion scores on the Maudsley Personality Inventory[6] from a group of 76.

Diagnostic value. Previous studies, using as criterion the presence or absence of after-effect, report varying percentages of organics who perceive the after-effect; however, none of the studies[4,5] using normals as controls reports complete failure to see the effect by any of the normal group. Thus there is recognized to be overlap between organics and normals in their ability to see the effect, but not in failure to see it. Of our eighty subjects, however, four saw no after-effect, even after prolonged stimulation, and it therefore seems unwise to assume that absence of the effect is evidence of brain-damage.

Holland and Beech[5] have suggested that the duration of after-effect may discriminate between normal subjects and those with brain damage. Apart from the four mentioned above, there were nine subjects in whom duration of after-effect was below that reported by Holland and Beech as the minimum for their normal group, and which, taken as a cut-off point, identifies eight out of their 21 organics without misclassification. 16 per cent of the 'normal' subjects in this study would, on this basis, be diagnosed as having brain damage.

In view of various discrepancies between these results and those previously reported, further work would seem necessary before anything can be asserted about the nature of the individual differences related to differences in length of after-effect, or about the diagnostic value of this phenomenon.

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